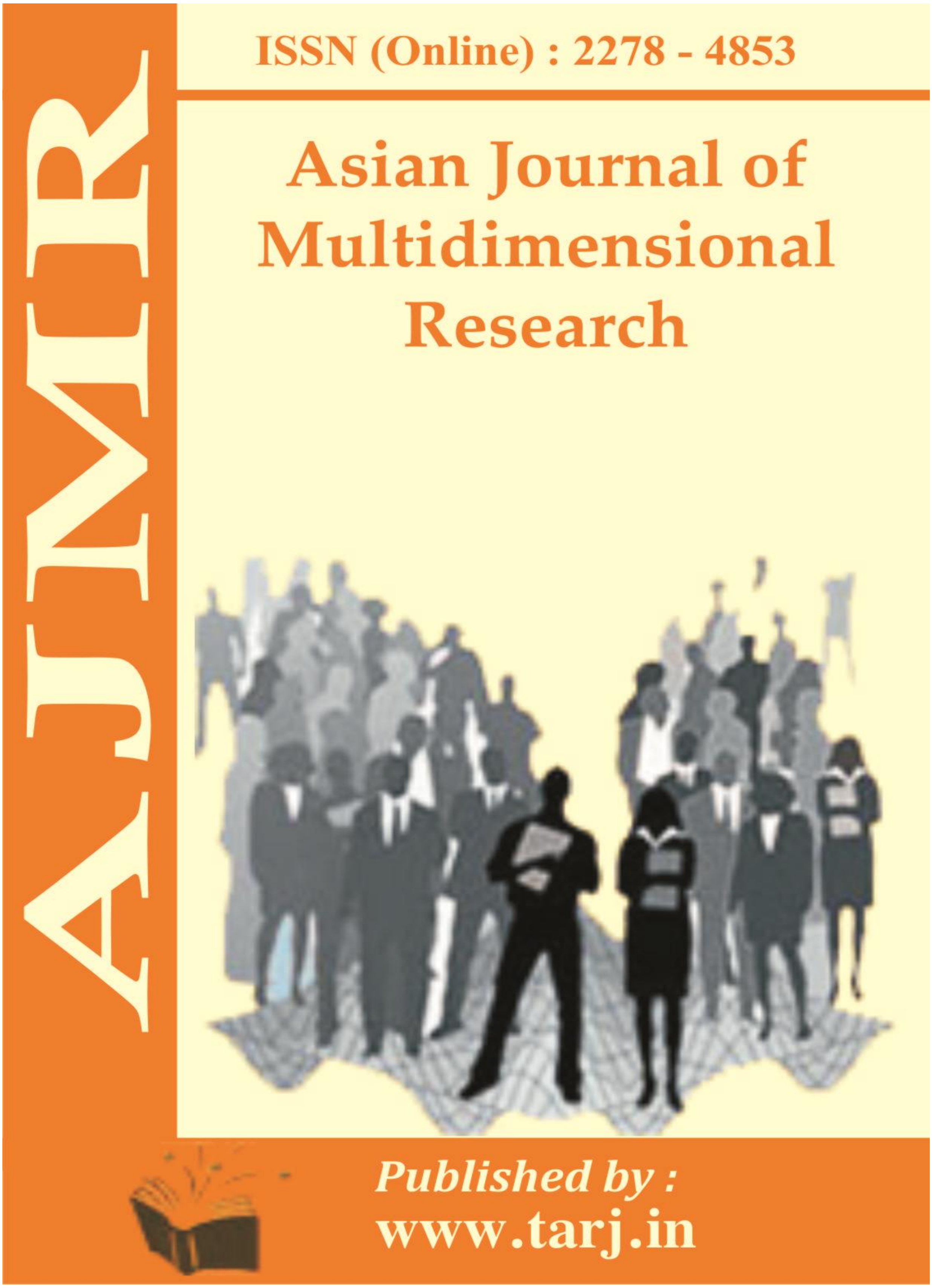
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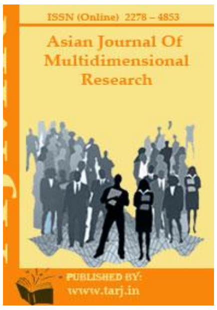
December 2022



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A BRIEF INTRODUCTION ON CASTING

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ABSTRACT

Casting is a common manufacturing method where molten material is poured into a mold cavity to create the desired form. It is a flexible and economical approach for creating intricate metal components utilized in many industries. This abstract gives a summary of the casting process and emphasizes its importance in the manufacturing industry. The creation of a mold, which can be composed of sand, metal, ceramic, or other materials, is the first step in the casting procedure. The liquid substance, usually a metal or alloy, is then poured into the mold cavity and given time to set. The casting is cleaned, polished, and quality-checked once the mold has been removed after the casting has solidified.The ability to create detailed and complicated shapes, the adaptability to work with a variety of materials, and the potential for efficient mass production are just a few benefits of casting. It is extensively employed in a variety of sectors, including the construction, automotive, and aerospace industries.

KEYWORDS: *Chamber, Casting, Die, Metal, Mold, Sand.*

INTRODUCTION

One of the earliest metal shaping processes used by humans is casting. It entails pouring hot metal into a cavity of a refractory mold and letting it cool before it solidifies. The solidified object is removed from the mold either by shattering or dismantling the mold. Casting is the term used for the solidified object, while casting process refers to the procedure used. Mesopotamia is where the casting process was most likely discovered around 3500 BC. During that time, baked clay was used to create flat things such as copper axes wood cutting instruments in open molds in many different parts of the world. Essentially, a single component was used to create these molds. The casting method advanced during the Bronze Age approximately 2000 BC. For the first time, a hollow socket core for casting items was created. Sand was roasted to form the core. Additionally, the lost wax technique was widely employed to create decorations through the casting process. From about 1500 BC, Chinese casting technology significantly advanced. China's casting industry has left behind proof of this. It took a lot of effort to create the ideal mold for highly detailed works down to the last detail, which meant that the castings made from the molds required very little finishing work. The Indus valley civilization is renowned for its widespread use of copper and bronze casting to create jewellery, weapons, tools, and household goods. However, casting technology did not significantly advance. They appear to have been familiar with all known casting techniques, such as open mold and piece mold, based on a variety of artefacts discovered at Indus valley sites. This chapter discusses the fluidity of molten metal, numerous casting methods, and various casting flaws that might appear during casting procedures[1]–[3].

Significance of Fluidity

The fluidity of the molten metal helps to produce castings that are sound and have few faults. It quickly and thoroughly fills the mold cavity while also preventing casting flaws like "misrun" from appearing in the finished item. Sound castings are produced when molten metal is appropriately poured at the proper temperature. The purpose of the gating system is to transfer clean metal into the mold cavity as smoothly as possible. In order to ensure sound casting, the casting gate must also be made to completely fill the mold cavity to eliminate casting flaws like misruns and to encourage feeding to create the right temperature gradients. It still primarily depends on knowledge to prevent casting flaws like misruns without using too high pouring temperatures. High flow rates are necessary to completely fill the intricate castings sections, but they shouldn't be too high to create turbulence.The capacity of the molten alloy to fill the mold may be impacted by metal temperature; this effect is known as metal fluidity. Included in this are the gas content, alloy analysis, and the molding material's capacity to extract heat. It is frequently beneficial to do a fluidity test to determine the metal's fluidity before pouring. A typical fluidity spiral test that is frequently performed for cast steel is shown in Figure 1.

The "fluidity" of an alloy is measured by how far, in inches, the metal travels through the spiral channel. Since temperature (super-heat) is the most important single variable determining the capacity of molten metal to fill mold, fluidity experiments, in which metal from the furnace is poured by controlled vacuum into a flow channel of adequate size, are highly helpful. The test serves as a reliable thermometer. The application of a straightforward spiral test in green sand on a core of steel melting in an electric furnace, where temperature measurement is expensive and inconvenient. The fluidity test is no longer necessary, with the exception of using it as a research tool for metals with lower melting points where pyrometer is problematic. Pouring is accomplished in small casting projects using ladles and crucibles.

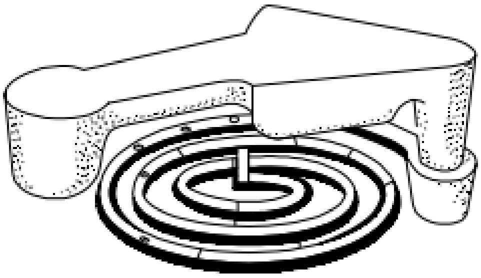

Figure 1: Shows Fluidity Spiral Test (wordpress.com).

Permanent mold or Die casting

In the United States and England, this procedure is referred to as gravity die casting and permanent mould casting, respectively. A permanent mould or metallic die is used in a permanent mould casting.No outside pressure is used to press the liquid metal into the mould cavity; instead, molten metal is solely poured into the mould under gravity. However, the pressure of the metal in the risers, etc. causes the liquid metal to solidify. The metallic mould may be recycled numerous times before being thrown away or rebuilt. These moulds are formed of cast iron, steel, bronze, anodized aluminium, graphite, or other suitable refractoriness that is dense, fine-grained, and heat resistant. To make it easier to remove the casting from the mould, the mould is created in two halves. It can be made with a horizontal dividing line like traditional sand moulds or a vertical parting line. A permanent mould has mould walls with a thickness ranging from 15 to 50 mm. More heat from the casting may be removed via the thicker mould walls. Fins or projections may be added to the exterior of the permanent mould to facilitate quicker cooling. The desired chilling result is achieved by doing this. The following list of this process's benefits, drawbacks, and applications is provided[4]–[6].

Advantages

(i) The casting produces a fine and dense grained structure.

(ii) Castings made using this procedure have no blow holes.

(iii) The technique is cost-effective for mass production.

(iv) The castings have fine grain structure due to the rapid rate of cooling.

(v) It is possible to produce a cast product with a close dimensional tolerance or work accuracy.

(vi) Accurate surface details and a good surface finish are achieved.

(vii) Sand castings that had casting flaws are corrected.

(viii) It is possible to produce goods at a high rate.

(ix) The procedure necessitates less work.

Disadvantages

(i) Metal molds are more expensive than sand molds. For large castings, the method is not viable.

(ii) The cooling effect causes the casting's surface to become hard.

(i) Refractoriness of alloys with high melting points.

Applications

i) This technique works well for small and medium-sized castings such pistons, connecting rods, oil pump bodies, carburetor bodies, and so on.

ii) It is a popular choice for casting non-ferrous metals.

DISCUSSION

Slush Casting

Slush casting is a development of metallic or permanent mold casting. It is frequently employed in the manufacture of hollow castings without the use of a core. The procedure is quite similar to casting metal in a metallic mold, with the exception that the mold is allowed to open before a set amount of molten metal has hardened to a certain thickness, leaving hollowness in the cast object. The method has several uses in the manufacture of items, including toys, novelties, statues, ornaments, lighting fixtures, and other items with hollow interiors.

Pressure Die Casting

In contrast to permanent mould or gravity die casting, pressure die casting forces molten metal into a metallic mould or die under pressure. In most cases, hydraulic or compressed air methods are used to create pressure. The pressure is kept constant while the casting solidifies and ranges from 70 to 5000 kg/cm2. The use of high pressure creates a unique capability for the manufacturing of complicated components at a reasonably low cost thanks to the rapid velocity with which the liquid metal is pumped into the die. In the USA, this procedure is known simply as die casting. The die casting machine needs to be appropriately constructed in order to retain and move a die while under pressure. There are two common molten metal ejection methods used in die casting setups, and they are as follows:

(i) Gooseneck or air injection management

(ii) Submerged plunger management

(iii) Hot chamber type

(iv) Cold chamber type

The majority of non-ferrous metals and alloys with low fusion temperatures are best suited for die casting, which is frequently utilized for mass production. The casting procedure is quick and affordable. Casting produces a surface that is so smooth that no finishing process is necessary. There are no sand inclusions or other cast imperfections possible in the material because it is thick and uniform. Castings' uniform thickness can also be preserved.

Zinc, aluminum, copper, magnesium, lead, and tin are the main base metals used in casting most frequently. Alloys are divided into high melting point (above 540°C) and low melting point (below 500°C) alloys based on their melting point temperature and capability for die casting. Alloys made of zinc, tin and lead fall within the low group. Alloys with copper bases and aluminum bases fall within the high temperature category.

Die-casting machines come in four primary categories, which are listed below.

1. Hot chamber die casting apparatus
2. Machine for cold chamber die casting.
3. A machine that blows air or uses a gooseneck
4. A vacuum die-casting apparatus.

Hot Chamber Die –Casting

The first and most straightforward to use die-casting machine is the hot chamber kind. It can create several hundred single impression castings weighing a few grammes each hour and up to 60 or more castings weighing up to 20 kg each in an hour. An essential component of the procedure is the melting unit of the setup. Due to the minimal superheat present in the molten metal, less pressure is required to press the liquid metal into the die. This procedure is depicted as a gooseneck, air-injection, submerged plunger, air-blown, or goose neck type machine. In Figure 2 shown the air blown or goose neck type die casting setup.It can do the following:

(i) Hold two die halves together at their final position.

(ii) Putting the die away.

(iii) Molten metal is injected into the die.

(iv) Opening the dice is

(v) Removing the casting from the diaphragm.

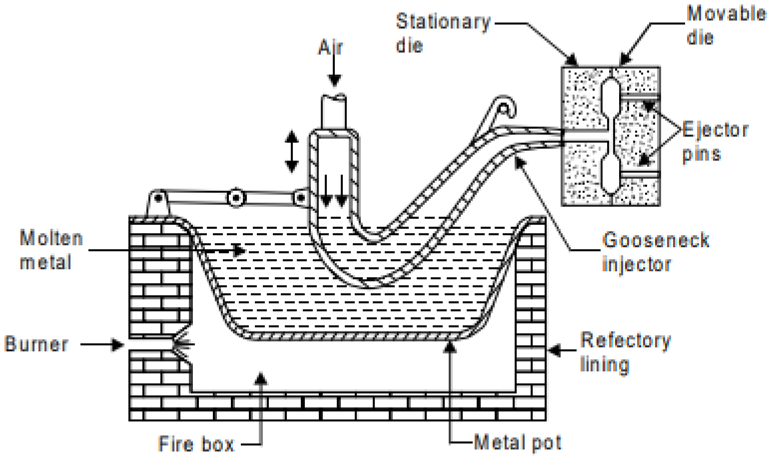

Figure 2: Shows an air blown or goose neck type die casting setup(wordpress.com).

The frame, the supply of molten metal and the molten metal transfer mechanism, the die-casting dies, and the metal injection mechanism are the four fundamental components of a die casting machine.Regarding its design and functionality, it is a straightforward machine. The arrangement includes a cast iron gooseneck that may, when required, be dipped beneath the molten metal's surface to receive the same. The cylindrical part and the curved passageways of the gooseneck are filled with molten metal. To force the molten metal into the closed die, the gooseneck is subsequently elevated and attached to an aircraft. To inject metal into the die, air pressure between 30 and 45 kg/cm2 is needed. Before pouring, the two mold parts are firmly fastened together. For tiny molds, straightforward mechanical clamps of the latch and toggle variety are sufficient.

The gooseneck is once more dipped beneath the molten metal to accept the metal once more for the following cycle once the die cast component has solidified. In order to receive molten metal for the creation of the following casting, the die halves are opened out, the die cast component is evacuated, and the die is closed. The cycle keeps going round and round. Large permanent molds typically require pneumatic or other power clamping tools. For aluminum, a permanent mold casting might weigh anywhere between a few gram to 150 kg. Alloy steel or dry sand are used as the core material for permanent molds. When they can be removed from the casting with ease, metal cores are employed. When the cavity that needs to be cored is such that a metal core cannot potentially be removed from the casting, a dry sand core or a shell core is preferred. The separating surface for one or both mold halves is machined to include the sprues, risers, runners, gates, and vents[7]–[9].

To reduce turbulence caused by incoming metal, the runner channels are slanted. The runner should always be at the casting's thinnest point, and the risers should be above the heavier parts at the top of the die. A refractory coating in the form of slurry is sprayed or brushed onto the mold cavity, riser, gate, and runner surfaces after the mold surfaces have been heated to the requisite temperature. Castings of aluminum and magnesium made in permanent molds are frequently coated with French chalk, which is calcium carbonate suspended in sodium silicate binder. Chills are put into the interior surface of the mold and are made of copper, brass, or aluminum. If air isn't forced through water passageways in the mold or cooling fins made outside the mold surface, water mist will provide a chilling effect. Commonly, a cold is employed to encourage directed solidification.

Cold Chamber Casting

The following are some ways that cold chamber die casting is different from hot chamber die casting.

1. In general, the melting unit is not a crucial component of the cold chamber die casting machine.

(vi)

2. When compared to hot chamber die casting machines, molten metal poured into cold chamber casting machines is typically at a lower temperature.
3. Based on this logic, a cold chamber die casting process must use pressures that are significantly greater (between 200 and 2000 kgf/cm2) than those used in hot chamber processes.
4. Molten metal with relatively lower temperature tends to be more fluid under high pressure.
5. Lower melting temperature and higher injection pressure result in castings with dense structures, sustained dimensional precision, and no blowholes.
6. Because the temperature of the molten metal is lower, die components are less subject to thermal stresses. However, in order to withstand greater pressures, the dies frequently need to be strengthened.

Advantages

1. The process is fairly speedy.
2. Mass production uses it.
3. This procedure results in castings with a significantly better surface polish.
4. It is simple to cast thin sections (0.5 mm Zn, 0.8 mm Al, and 0.7 mm Mg).
5. Strong toleration
6. An extremely clear and crisp surface
7. There are less rejections.
8. Production costs are lower
9. The processes take up less room
10. A very efficient process
11. The die has a long useful life.
12. All castings are the same size and shape.

Disadvantages

1. Die prices are expensive.
2. Only thin castings are able to be made.
3. A unique skill is needed.

4. Some air is constantly trapped in castings, generating porosity, unless particular care are taken for evaluating air from die-cavity.
5. Low production is not appropriate.

Applications

1. Body of a carburetor
2. Brake cylinders with hydraulics
3. Refrigerant castings
4. A washing machine
5. Automotive pistons and connecting rods
6. Oil pump structures
7. Gear covers and gears
8. Castings for missiles and aircraft, and
9. Typewriter parts

Advantages of Die Casting over Sand Casting

1. Die casting takes up less room on the floor than sand casting.
2. It assists in providing precise dimensional control, which lowers the cost of machining as a result.
3. It offers a better surface polish overall.
4. Die casting can be used to create thin sections of complex shapes.
5. Die casting allows for the close tolerance production of more accurate shapes
6. Die-casting results in castings that are typically less faulty.
7. It generates casting that is more resonant than sand casting.
8. The process is pretty speedy.
9. It produces at a high pace of up to 800 castings each hour.

Shell Mold Casting

Recently developed casting methods for mass production and smooth surface finish include shell mould casting. During the Second World War, Germany was where it all began. It is also known as the C process or Carning. It involves creating a mould with two or more thin shells (shell line portions) that have the texture of thermosetting resin-bonded sands and are reasonably hard and smooth. The 0.3 to 0.6 mm thick shells are manageable and storable. Shell moulds are created to allow for simple assembly of machining components. Metal is poured either vertically or horizontally, holding them in place using clamps or adhesive. Rocks or a large amount of heavy porous material is used to support them. Sand, dry powder, and thermosetting resin are completely combined in a muller[10].

As shown in Figure3, the entire shell molding casting process is carried out in four steps.This procedure involves placing a pattern on a metal plate and coating it with a 20:1 mixture of fine sand and phenol resin. First, the design is heated, and for simple separation, silicon grease is sprayed on the heated metal pattern. The pattern is coated with resin-bound sand and heated to between 205 and 230°C. A firm coating of sand is created over the pattern after 30 seconds. In an oven, pattern and shell are heated and treated for 60 seconds at 315°C.

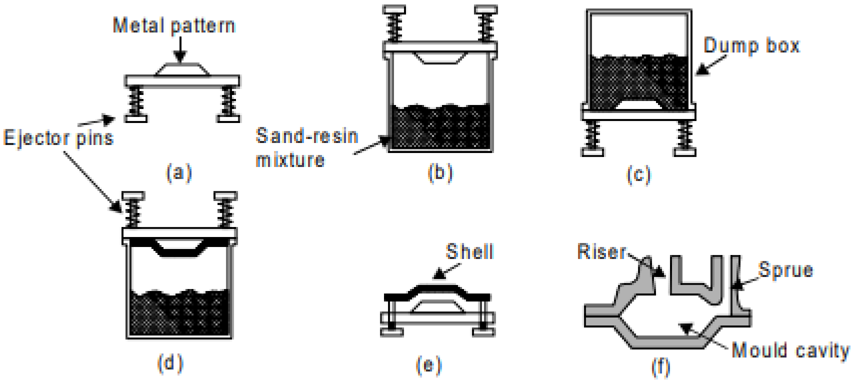

Figure 3: Shows Shell Mold Casting Process (wordpress.com).

CONCLUSION

A fundamental manufacturing procedure called casting makes it possible to produce intricate metal components. It offers adaptability, affordability, and the capacity for mass production. To guarantee high-quality castings, however, significant consideration must be given to mold design, material choice, and process control. As technology and materials continue to grow, casting develops as well, spurring innovation and satisfying the needs of contemporary manufacturing sectors.

REFERENCES

[1] K. Herfurth and S. Scharf, “Casting,” in *Springer Handbooks*, 2021. doi: 10.1007/978-3-030-47035-7_10.

[2] M. Mukhtarkhanov, A. Perveen, and D. Talamona, “Application of stereolithography based 3D printing technology in investment casting,” *Micromachines*. 2020. doi: 10.3390/mi11100946.

[3] G. Shao, D. A. H. Hanaor, X. Shen, and A. Gurlo, “Freeze Casting: From Low-Dimensional Building Blocks to Aligned Porous Structures—A Review of Novel Materials, Methods, and Applications,” *Advanced Materials*. 2020. doi: 10.1002/adma.201907176.

[4] J. wu Kang and Q. xian Ma, “The role and impact of 3D printing technologies in casting,” *China Foundry*, 2017, doi: 10.1007/s41230-017-6109-z.

[5] K. Herfurth and S. Scharf, “Volume 15 Casting,” *Springer Handbooks*, 2021.

[6] M. Niinomi, “Casting,” in *Metals for Biomedical Devices*, 2019. doi: 10.1016/B978-0-08-102666-3.00011-0.

[7] A. Javaid and F. Czerwinski, “Progress in twin roll casting of magnesium alloys: A review,” *Journal of Magnesium and Alloys*. 2021. doi: 10.1016/j.jma.2020.10.003.

[8] S. R. Sama, T. Badamo, P. Lynch, and G. Manogharan, “Novel sprue designs in metal casting via 3D sand-printing,” *Addit. Manuf.*, 2019, doi: 10.1016/j.addma.2018.12.009.

[9] I. Nelson and S. E. Naleway, “Intrinsic and extrinsic control of freeze casting,”

Journal of Materials Research and Technology. 2019. doi: 10.1016/j.jmrt.2018.11.011.

[10] A. K. Sheikh, M. A. A. Khan, Z. M. Gasem, and H. Iqbal, “Enhancing teaching and research skills in metal casting through a virtual casting lab,” *Eng. Reports*, 2021, doi: 10.1002/eng2.12362.

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DISCUSSION ABOUT THE CARPENTRY PROCESSES

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ABSTRACT

In the manufacturing sector, carpentry is essential to the production of high-quality goods and to assuring their precision and durability. This abstract offers a summary of the importance of carpentry in manufacturing processes, emphasizing its part in molding and putting together various components. It also covers the value of qualified carpenters and how to incorporate contemporary technologies to improve industrial effectiveness. In the manufacturing industry, carpentry refers to the fabrication and assembly of woodworking components used in the creation of furniture, fittings, cabinetry, and other goods. In order to mold and build complex elements, skilled carpenters use specialized equipment, appropriate materials, and their ability to read design drawings. Their skill ensures the components are fitted and aligned precisely, improving the overall quality and performance of the created goods.

KEYWORDS: *Glue, Plywood, Seasoning, Timber, Wood, Work.*

INTRODUCTION

The main output of the forest is wood made from trees. It has received widespread acceptance as a raw material for producing appliances or other wooden goods. Wood has been used as a significant source of heat generation since ancient times. It has been used as a mazor construction material to create housing, which is a basic human need. It became an extremely important particular material for building boats and for piling to support ports and railway tracks as civilization developed. But in more recent times, thanks to improvements in wood chemistry, wood has come to be appreciated for its value in producing inexpensive useful items like paper, furniture, textiles, plastics, and a vast array of chemicals and extractives. In some goods, plywood and other hardwood products have surpassed metallic and ceramic materials. Heartwood, sapwood, pith, cambium layer, bast, medullary rays, and bark are also present in compressed wood.

Hardwoods and softwoods are two popular categories for commercial timbers. Oak and beech are examples of hardwoods, both of which have broad leaves. Softwoods, on the other hand, have slender, needle-like leaves like pine and spruce replaced a few metals with die castings and gears. In Europe, wood has been used as a source of wood gas to power vehicles during times of conflict. Similar to cotton, wool has also been used to make garments. The most popular shop, known as a carpentry shop, is where the beneficial work on wood is typically done. Cutting, shaping, and connecting wood and other materials together to create wood goods make up the work done in carpentry shops. Consequently, a carpentry shop works with wood, a variety of tools, and the craft of joinery. In wood, there are two different sorts of cells: those that run along to the length of the wood and those that radiate outward from its centre. According to how they grow, trees are typically divided into exogenous and endogenous forms.

Exogenous kinds are also referred to as outward-growing trees that generate commercial-grade wood. While the innermost timber continues to mature, they grow outward, with the additional growth that takes place each year taking place on the outside of the trunk just beneath its bark. The tree adds a new growth ring or yearly ring each time the growth cycle is finished. Since each of these rings reflects a year of growth, it is possible to calculate the age of a tree by counting them[1].

Inward-growing trees are another name for endogenous trees. Every new layer of sapwood is added from the inside rather than the outside as they grow inward. Examples of such endogenous trees are cane, bamboo, and coconut trees.Wood that is suited for engineering, construction, and building uses is referred to as "timber" in common parlance. After the tree has reached full growth, the main body of the tree is cut into the appropriate sizes to produce timber. The annual rings that make up the structure are made of wood.

Types of common timbers their qualities and uses

In India, you can find Shisham, Sal, Teak, Deodar, Mango, Mahogany, Kail, Chid, Babul, Fir wood, Walnut, and Haldu, among other popular and well-known varieties of timber. Deodar, Chid, Kail, Fir Wood, and Haldu are classified as softwoods, whereas Shisham, Sal, Teak, Kiker, Mango, and Walnut are classified as hardwoods. Other foreign woods that are frequently utilised in India are Ash, Burma, Hickory, Oak, and Pine.

1. Shisham has golden and black brow stripes and is a dark brown colour. It is extremely difficult to work with and typically wears or blunts the cutting tool's sharp edge very quickly. It can be found in India in the Himalayan range at elevations between 1000 and 1500 metres and in dense forests. It is regarded as a very strong and long-lasting wood and is mostly used to make a wide range of furniture, tool handles, beds, cabinets, bridge piles, plywood, and other household items.
2. Sal is a rose-brown colour that gradually changes to dark brown. This wood is frequently found in the Himalayas, M.P., and U.P. of India. It is quite challenging to work in and free from white ant attacks. It has a subpar finish, thus Sapwood is added internally rather than externally. Examples of such endogenous trees are cane, bamboo, and coconut trees.

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2. Sal is a rose-brown colour that gradually changes to dark brown. This wood is frequently found in the Himalayas, M.P., and U.P. of India. It is quite challenging to work in and free from white ant attacks. Because of its poor finish, it is not used for decorative furniture. It has several uses, including the construction of doors, windows, cots, wooden handles, and furniture and railway sleepers.
3. Teak wood is tough, expensive, and has a wide range of uses. It is offered in dark brown or golden yellow. Its unique stripes enhance its charm. It can be found in M.P. in India. It keeps a nice polish and is highly powerful and long-lasting. It is mostly used to create high-quality ships, plywood, and furniture.
4. When soft, deodar is white in color. But when it gets tough, it begins to look bright yellow. It is sturdy and long-lasting. When smelled, it releases aroma. Because it has some oil, insects are less likely to attack it. It is typically found in the Himalayas between 1500 and 3000 meters. It is used to make doors, furniture, patterns, railway sleepers and other things.
5. Mangos are brown in color and are easily moldable into a variety of things. In India, it is frequently used as a cheap wood to make doors, packing cases, toys, and subpar furniture.
6. Mahogany has a reddish brown color and is extremely robust when dry. Additionally, it has oil in it that shields it from insect attacks. It is frequently used in the production of cabinets, exquisite furniture, pattern-making work, etc.
7. Kail wood has an excessive amount of knots. This wood is frequently found in the Indian Himalayas. It produces a close-grained, tough, long-lasting wood that is simple to paint. It is frequently used to create inexpensive furniture, wooden doors, packing cases, etc.
8. Chir is another name for Chid. When it's soft, it's a dark brown color, but when it's firm, it's a reddish brown color. It has dark brown stripes on it. It is used for interior homework and has an oily smell.
9. Babul is a durable, pale red, close-grained wood that is used to make tool handles and other items.
10. Fir wood is light brown in color, as opposed to the darker brown of the tougher yet softer species. Insects can quickly attack it. It is frequently used to create doors, packing containers, and drawers, among other things.
11. The wood variant walnut is excellent for fending off attacks from white ants. It is easily polish able in a better method. This wood is typically used to create furniture, cabinets, musical instruments, decorative items, etc.
12. Haldu is white in color before being cut, however it turns yellow after being sliced. It can be satisfactorily dried and polished. It is frequently employed to create little items like stools, picture frames, trays, cabinets, etc.

DISCUSSION

Felling, conversion and seasoning of wood

Felling a tree refers to the act of cutting down a live, standing tree in order to obtain lumber. Trees are cut down when it is appropriate. In order to acquire the greatest amount and highest quality of wood, it is best to cut the tree as soon as it reaches its full development or maturity age. If a young tree is cut down, a lot of sapwood that may not be very helpful for carpentry work will be left behind. Contrary to this, the most valuable component of the tree's timber will be prone to degradation if it is left standing for a long time after reaching maturity. Therefore, it is crucial to take the necessary precautions to ensure that felling only occurs when it is necessary. The right timing to cut down a tree mostly depends on its age and the time of year. Because the sap of the tree is at rest during these times, cutting trees for use is typically done in the middle of the summer or the middle of the winter, which reduces the likelihood that any useable wood will decay. Whether a tree is a softwood or hardwood determines how long it takes for it to mature. Softwood trees reach maturity in 80 to 100 years, whereas hardwood trees require 130 to 200 years to reach maturity. The branches are removed from the tree after it has been cut down to the trunk, producing a log-like shape.

Conversion is the process of cutting wooden logs into usable dimensions and configurations (boards, planks, squares, and other planes sections and sizes, etc.) for market or commercial requirements. Two processes, quarter and rift sawn process and plain, through, through sawn process, are used to carry over conversion before seasoning. Quarter sawing virtually eliminates the possibility of warping, which makes it possible to employ plain lengths of wood for high-quality work. In the construction of cabinets, furniture, and decorations, quarter-sawn portions make excellent wood. The planting of fresh trees is equally important and should be done periodically.

Sawing timber logs into various commercial sizes is referred to as conversion. The provision of a sufficient tolerance for shrinkage that occurs during the seasoning of sawn or converted wood is a prominent characteristic of conversion. Depending on the type of wood and the time of cutting, wood typically shrinks from 3.2 to 6.4 mm. The three most popular conversion techniques are mentioned below.The first technique is known as flat or conventional cutting and is the most basic sawing operation, however the cut pieces are prone to warping. As a result, the wood that was cut using this method cannot be regarded as quality work. This technique involves making numerous parallel saw cuts into the appropriate shapes to divide the timber log into a number of boards.The second technique is tangential cutting, in which the boards are cut so that their widths are perpendicular to the annual rings. The wood is quickly dried out and there is less waste during the cutting process, although it may warp like flat sawn wood.

The third method, referred to as quarter or radial sawing, involves sawing the logs of wood so that the breadth of the boards runs parallel to the medulary rays, or across the section of the log. This method of sawing virtually eliminates the common flaw of warping, making the wood excellent for all types of woodworking including cabinet-building, decorating, and framework. The following marketable products are made from trees: posts (square pieces of timber 175–300 mm wide or round pieces 175–300 mm in diameter), deals (parallel side pieces about 225 mm wide and 100 mm thick), planks (50–100 mm thick, 275–300 mm wide, and 3–7 meters long), and boards or battens (25–50 mm thick and 125–175 mm wide). For building construction, sizes of timber (Kail, Deodar, etc.) available on the market include 10' 10" x 5", 12' 10" x 5", 10' 8" x 5", 10' 8" x 4", etc.

When wood is "seasoned," its moisture or sap content is decreased to the point that it can no longer dry out under regular use conditions. Seasoning's primary goal is to lessen the undesirable moisture content of the wood. The shrinkage of the wood occurs as the moisture in the cell walls evaporates, and it is most pronounced along the growth rings. During seasoning, additional flaws like shaking and warping may appear. Green or unseasoned wood should only be utilized for rough work because of these reasons. The lumber won't shrink, twist, or swell after being properly seasoned before use. It is vital to season wood before using it in order to attain the proper moisture content, prevent fungus decay, minimize insect attack, increase wood strength, and reduce war page. There are two types of seasoning: natural seasoning and artificial seasoning. Usually, natural seasoning takes place in smoke, water, or the air. The oldest way of drying wood is air seasoning, which solely depends on the unrestricted passage of air around the wood to evaporative remove moisture[5]–[7].Figure. 1 shows timber stack in shade for air seasoning

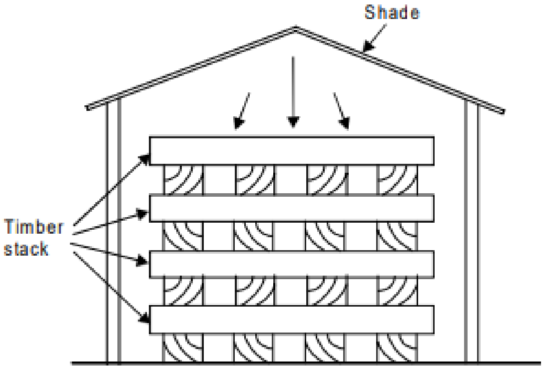

Figure 1: Shows timber stack in shade for air seasoning (wordpress.com).

The timber baulks are submerged in water for 15 to 20 days during water seasoning. The sap of the wood is periodically washed away by the running water. The wood is then removed and cured outside for about a month. Seasoning with water reduces the strength of the wood but takes less time than seasoning with air. The timber is less likely to twist, split, and deform thanks to water seasoning. This seasoning technique is ideal for seasoning sap-filled green wood. Timber is less susceptible to rot and decay after this seasoning process. When wood is seasoned with smoke, it is dried using the smoke from untreated wood and fallen leaves. The wood in boats is seasoned with smoke. Heat and humidity are applied simultaneously to artificially season food, fast and precisely reducing the moisture content. In contrast to natural seasoning, which makes wood soft, chemical seasoning makes wood tougher. As seen in Fig. 2, one significant method of artificial seasoning is kiln seasoning, which uses a forced flow of warm air to quickly reduce the moisture content of the wood while seasoning it.

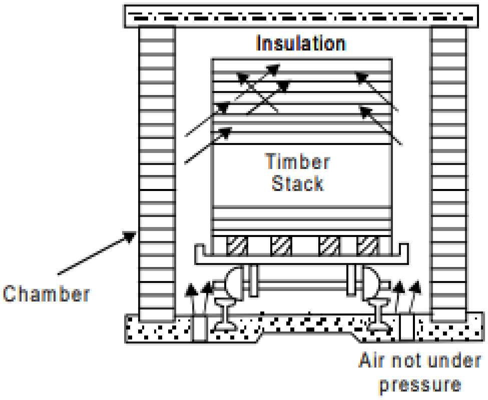

Figure 2: Illustrates timber stack in kiln seasoning (wordpress.com).

Defects in Timber

Three basic categories can be used to broadly classify defects in timber.

1. As a result of trees growing abnormally
2. Because of conversion, seasoning, or
3. Because of insects and fungus.

Defects Due to Abnormal Growth in Trees

Natural defects caused by the aberrant growth of trees include knots, stakes, twisted fibre, and rind galls.

In a lot of trees, knots are common. They weaken the timber by rupturing the fibre continuity. These flaws could be either dead or living. A knot fault is depicted in Figure.3. The wooden piece will develop a knot hole where a dead knot has emerged. It develops when a branch is severed before the tree has fully grown. When a limb breaks away from the tree after it has been felled, a live knot develops. Live knots have a tendency to fracture but won't come undone and drop out of place. This gives fungal access points through which to attack the wood. Dead knots in lumber render the wood unsuitable for structural usage, but only if they are not too huge and are not too close to the edge of the plank.Figure 3 shows knot defect in timber (wordpress.com).

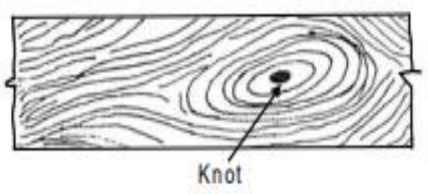

Figure 3: shows knot defect in timber (wordpress.com).

Timber shakes are breaks in the grain that frequently originate from uneven seasoning.They could be of the upset, radial, heart, star, or cup kind. A shake in which the fracture occurs against the grain is called an upset or rupture. This is frequently observed in mahogany and is assumed to be brought on by the shaking of the timber during harvesting.A tree's fibers may occasionally twist as a result of wind activity in the branches. Twisted fibers defect in lumber is the name given to this flaw. The inclinations of the wood's fibers with respect to its axis vary. They are no longer parallel to the wood's axis. Timber with twisted fibers is challenging to work with and impossible to smooth out. Rind gall is a defect brought on by the plants' atypical development. It is the wound left behind on the tree after a branch snaps off in pieces or is cut. At that moment, decay might happen.

Defects due to conversion and seasoning

Shakes, warping, bowing, twisting, diamonding, casehardening, and honey combing are some of the defects caused by the conversion and seasoning of wood. These and other significant flaws are detailed below.One or a combination of cup, bow, crook, and twist are examples of warping, which is a type of deviation from a true or plain surface. A board that has been tangentially sawn may always warp. This manifests as a hollowing or cupping over the board's face, and when wide flat boards are needed, this poses a significant disadvantage.

When thin boards are cut from a log with a bent longitudinal grain, a wind or twist fault results. The board has a propensity to spirally warp in this way. Diamonding in wood refers to the propensity of square-cut pieces taken from specific parts of the log to take on a diamond form. When the piece was cut with the growth rings running diagonally, the unequal shrinking between the summer and spring growth caused it to pull out of shape[8]–[10].

Defects due to fungi and insects

Fungi, dryrot, and wetrot are three examples of defects brought on by fungi and insects in wood, and they are addressed here.Fungi in wood consume the wood as food and obliterate it. It causes deterioration by acting on the wood's cells and tissues. Wet rot and dry rot are two different forms of faults in wood caused by fungi and insects.A form of fungus called dry rot grows on dry wood and feeds on and decomposes damp wood. Infected wood soon loses weight and develops the look of being severely scorched by fire, except that it is brown rather than black and collapses when applied light pressure, giving rise to the name "dry rot." Since this fungus cannot grow on wood with a sap content of less than 20%, using seasoned wood and maintaining it in a dry environment should be enough to prevent it.

Wood that has experienced wet rot is damaged by moisture. Due to fungi's attack on living trees, the wood seems to be moist. The affected areas of wood are reduced to a powdery, gray-brown substance. Wet rot can be prevented by using well-seasoned wood that has been painted or otherwise treated.The wood is attacked by insects like beetles, borers, and white ants, which render it useless.In temperate, tropical, and subtropical environments, beetles are frequently encountered. Beetles eat wood as a food source. Borers drill holes in the wood in order to find a place to live. In places with warm climates, white ants or termites are quite prevalent. They damage the wood and hollow it out from the inside. Insecticides can be used to control the insect invasion. Another technique involves placing the timbers in a kiln, where the pests are suffocated by heat and steam.

Timber Preservation

The need to preserve wood from fungus and insect damage cannot be overstated. If a product made of wood, such as doors, windows, poles, etc., is exposed to the elements, it needs to be protected. Preserving the wood is a considerably more affordable option for extending its life. The purpose of treating wood with a preservative is to make it resistant to deterioration even when it gets quite damp and to stave off attack by insects that devour wood. The majority of wood preservatives fall into one of three categories: organic solvent compounds, water-soluble types, and tar-oil derivatives like creosote.

Characteristics of Good Timber

Timber is sound, bright, and free from any discoloration. It is also free from knots, insect attacks, excessive moisture, discolouration, twisted fibres, cup and ring wobble, and discoloration. It is solid and has annual rings, but the centre is not hollow. For a specific function that can be easily worked, wood should be well-seasoned.It should have strong fire resistance and straight fibres. If you push nails into it, it shouldn't split. During the sawing process, it shouldn't get clogged with the saw teeth. Timber ought to be quite ideal for painting and polishing.

Factors Influencing Timber Selection

Its durability, workability, weight, hardness, cohesiveness, elasticity, type of texture, type of grain, resistance to fire, resistance to various stresses, ability to retain shape, suitability for polishing, and suitability for painting are the factors influencing the selection of timber.

Plywood and its Applications

Plywood and other manufactured boards have gradually replaced solid wood in the production of furniture, fixtures, panelling, and many other types of building work over the past number of years. Typically, three or more sheets of veneer are bonded together to form plywood, with the grain of the subsequent plies being laid crosswise. Given that wood is strongest down its grain, when veneer plies are bonded against one another, strength is spread along the length and width of the piece. In opposed to plain wood, plywood may be purchased in much bigger sizes without shrinking or warping.

Plywood can be used to create moulded plywood boats, television, and radio cabinets. The plywood can easily resist humid conditions. Even the hardest hardwoods cannot compare to the strength and lightness of plywood. Plywood can be fastened with screws and nails very close to the edge without risk of splitting. On plywood, a premium surface quality is simple to obtain.

The creation of heat- and moisture-resistant adhesives has facilitated the use of laminated members in heavy truss construction, the joining of short lengths to create longer pieces, and the glueing together of narrow boards to create broader ones. Sheathing, interior finishing, sub flooring, under-roofing, panelling, flooring, cabinets, furniture, shelving, partitions, ceilings, containers such as baskets, boxes, crates, trunks into boats, toys, tables, woodenware, and repair work in garages and basements are just a few uses for plywood in construction.

Miscellaneous Material in Carpentry Shop

In addition to lumber, a variety of other materials are employed in carpentry shops. Dowels, nails, screws, adhesives, paints, and varnishes are the main components. Below is a basic description of this kind of information.

Dowels

Dowels are small wooden objects with specific nails that are often crafted by the carpenter from bamboo or other similar wood. They are employed to fasten various wood structural elements. The two components or parts that will be connected together must first have a hole drilled through them. The dowel is then driven through the pieces once they have been assembled in the right position for joining.

Nails

Drawn wire made of brass, copper, low carbon steel, or malleable iron rods is used to make nails for woodworking. Wire nails are those created from drawn wires, and clasp nails are those manufactured from rods. The clasp nails are more capable of holding than wire nails. The clasp nails are typically used for heavy work, whilst the wire nails are utilised for light and medium work. Nails are primarily used to hold various wood components together and reinforce bonded seams. Their length and diameter serve to describe their size. In the market, these are sold by weight.

Screws

Screws are fasteners that are primarily used to secure metallic fittings like hinges and hasps in timber structures. They are made from bright drawn wires or thin rods.

Adhesives

Adhesives are substances that cling to surfaces, such as glue, paste, cement, and mucilage, and can be used to permanently join wooden parts to one another. It is frequently used to link the boards together face-to-face to enhance thickness or edge-to-edge to create a larger surface. It is used to adhere together relatively small surface areas, such as woodworking joints, as well as huge surface areas of material, such as when installing veneers. A good connection between the wooden components is maintained by an effective adhesive, sticking paste, or glue under the service conditions that the joint must resist. In joinery work and many other typical types of woodworking, it is commonly necessary to join together hardwood boards edge to edge to create a bigger surface or face to face to enhance thickness. It can be applied in a hot or cold environment. The former, also referred to as liquid or cold glue, is employed when a slower and weaker setting is preferred. It is known as cooked glue when it is hot applied, allowing a particularly strong and long-lasting sort of bond between the neighboring layers of wood pieces. Casein glue, animal glue, vegetable glue, albumen glue, synthetic resins, polyvinyl acetate (PVA), paint and varnish, rubber cement, and plastic cement are a few of the commercially available adhesives that can be categorized. A few significant examples of these adhesives are briefly mentioned below.

Casein glue

By adding an alkali to the curd of skim milk, casein glue is created. It is sold in the market in powdered form for commercial use. While usage, it can be turned into a paste by adding water. When squeezed, it swiftly squeezes out of the joint despite being thicker than animal glue. The carpenter has enough time to bond and fasten his job because this glue takes 15 to 20 minutes to fix a wooden joint. Commonly used casein glue is a powerful, water-resistant adhesive. It is utilized particularly in wooden parts made for furniture, boats, veneering, beams, and other structures that are regularly exposed to high humidity.

Animal glue

Hoofs, bones, hides, and other animal waste are used to make this glue. These substances are produced and processed into sheets, flakes, or powder. The adhesive should be heated after spending the night in cold water before to use. Typically, it is applied hot and quickly sets. Commercially, it is also offered in liquid form, which can be applied directly without being heated first. It's crucial to remember that this glue needs to be used right away after heating. Avoid repeatedly heating objects because doing so weakens the glue's binding and reduces its fluidity owing to water evaporation, making the glue thicker.

Vegetable glue

It is made from starch that is extracted from tree roots, grains, and corns by soaking them in acid and grinding them into a powdered form. It is mostly utilized in plywood production and is not well suited for other types of work[11]–[13].

CONCLUSION

The manufacturing sector relies heavily on carpentry because it offers the essential skills and methods required for the creation and assembly of components. The production process benefits from the accuracy, workmanship, and attention to detail provided by skilled carpenters, who guarantee that the finished goods fulfil strict criteria for quality and functionality. The effectiveness and precision of carpentry in production are further improved by the incorporation of current technology like CAD software and CNC equipment. Designers can develop intricate digital models using CAD software, which facilitates accurate measurements and realistic simulations. Various carpentry activities are automated by CNC equipment, resulting in reliable and precise production results.

REFERENCES

[1] B. Schilling, Y. Taleb, J. Russell Carpentery, M. Balducciz, and T. W. Williamsx, “Operational experience with the wald sequential probability ratio test for conjunction assessment from the magnetospheric multiscale mission,” 2016. doi: 10.2514/6.2016-5424.

[2] M. Geiser, M. Bergmann, and M. Follesa, “Influence of steel properties on the ductility of doweled timber connections,” *Constr. Build. Mater.*, 2021, doi: 10.1016/j.conbuildmat.2020.121152.

[3] B. S. Law, T. Brassil, L. Gonsalves, P. Roe, A. Truskinger, and A. McConville, “Passive acoustics and sound recognition provide new insights on status and resilience of an iconic endangered marsupial (koala Phascolarctos cinereus) to timber harvesting,” *PLoS One*, 2018, doi: 10.1371/journal.pone.0205075.

[4] L. T. Bennett and M. A. Adams, “Assessment of ecological effects due to forest harvesting: Approaches and statistical issues,” *Journal of Applied Ecology*. 2004. doi: 10.1111/j.0021-8901.2004.00924.x.

[5] G. M. Kondolf, J. G. Williams, T. C. Horner, and D. Milan, “Assessing Physical Quality of Spawning Habitat,” *Am. Fish. Soc.*, 2008.

[6] P. J. Burgess and A. Rosati, “Advances in European agroforestry: results from the AGFORWARD project,” *Agrofor. Syst.*, 2018, doi: 10.1007/s10457-018-0261-3.

[7] M. Sterley, E. Serrano, and B. Källander, “Building and construction: Timber engineering and wood-based products,” in *Adhesive Bonding: Science, Technology and Applications*, 2021. doi: 10.1016/B978-0-12-819954-1.00021-6.

[8] J. Wells, F. Haddar, M. L. Uhde, and A. Sy, “Shelter provision in the context of deforestation: some evidence from Mali,” *Habitat Int.*, 1998, doi: 10.1016/S0197-3975(98)00023-X.

[9] H. Kilpeläinen, J. Lindblad, H. Heräjärvi, and E. Verkasalo, “Saw log recovery and stem quality of birch from thinnings in southern Finland,” *Silva Fenn.*, 2011, doi: 10.14214/sf.117.

[10] A. E. Alekseev, I. O. Dumanskij, and A. V. Prokhorov, “Plate Dampers in the Tensioning Plate Dampers in the Tensioning,” *Lesn. Zhurnal (Forestry Journal)*, 2021, doi: 10.37482/0536-1036-2021-5-142-149.

[11] Pugh *et al.*, “Michigan Forests 2014,” *Resour. Bull. NRS-110. Newt. Square, PA US Dep. Agric. For. Serv. North. Res. Station. 154 p.*, 2017.

[12] T. DeGomez and M. R. Wagner, “Culture and use of black locust,” *Horttechnology*, 2001, doi: 10.21273/horttech.11.2.279.

[13] D. Page-Dumroese, M. Jurgensen, D. Neary, M. Curran, and C. T. Rocky, “Soil quality is fundamental to ensuring healthy forests,” *Gen. Tech. Rep. - Pacific Northwest Res. Station. USDA For. Serv.*, 2010.

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DESCRIPTION OF DRILLING MACHINE

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ABSTRACT

For making holes in workpieces, drilling machines are crucial equipment in many industries. The kinds, components, and applications of drilling machines are highlighted in this abstract. Additionally, it covers the significance of appropriate drilling methods and factors to take into account for successful drilling operations. The relevance of drilling machines as adaptable and essential equipment in contemporary manufacturing and building operations is summarized in the conclusion.

KEYWORDS: *Drilling, Machine, Cutting, Column, Edge, Spindle.*

INTRODUCTION

Making a circular hole by using a drill as a cutting tool to remove a quantity of metal from the work is known as drilling. A drill is a rotating end-cutting instrument that has one or more cutting lips and, more often than not, one or more flutes for chip passage and cutting fluid entry.A machine tool called a drilling machine is made specifically for drilling holes in metals. It ranks among the most crucial and functional machine tools in a workshop. The drilling machine can also be used for a variety of additional tasks in addition to drilling round holes, including counter-boring, countersinking, honing, reaming, lapping, sanding, etc.

Construction of Drilling Machine

In a drilling machine, the drill is fed into the stationary workpiece while being spun along its axis. Figure1 depicts various components of a drilling machine, which are described further.

i. The drill spindle receives rotary motion from the head's electric motor, V-pulleys, and V-belt at various speeds.

ii. The alloy steel spindle is manufactured. In a sleeve, it rotates as well as rises and falls. For the drill to be able to be fed into the workpiece or removed from it while drilling, a pinion contacts a rack mounted to the sleeve to allow vertical up and down motion of the spindle. V-belt and V-step-pulleys are used to modify the spindle speed or drill speed. Larger drilling machines have gear boxes for the aforementioned function.

iii. The drill bit is held by the drill chuck, which is attached to the drill spindle.

iv. The drilling machine’s column supports the adjustable work piece table. It is movable both horizontally and vertically. Slots are typically present in tables to allow for the secure attachment of a vice or workpiece.

v. The drill press construction is supported by a base table that is made of a sturdy casting. The column, in turn, supports the table, head, and other objects thanks to the base. The head and the table are supported by the column, which is a vertical round or box piece that sits on the base. Depending on the needs of the workpiece, the round column may have rack teeth cut into it so that the table can be raised or lowered [1]–[3].

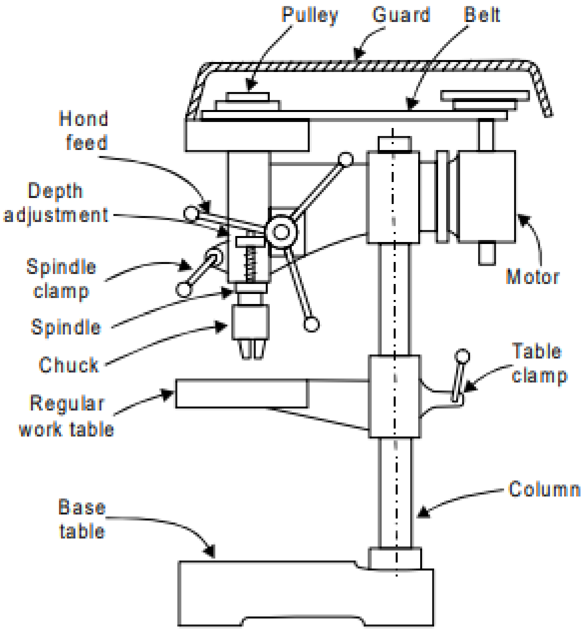

Figure 1: Shows Construction of drilling machine (wordpress.com).

Types of drilling machine

Drilling machines are classified on the basis of their constructional features, or the type of work they can handle. The various types of drilling machines are:

(1) Portable drilling machine

(2) Sensitive drilling machine

(a) Bench mounting

(b) Floor mounting

(3) Upright drilling machine

(a) Round column section

(b) Box column section machine

(4) Radial drilling machine

(a) Plain

(b) Semi-universal

(c) Universal

(5) Gang drilling machine

(6) Multiple spindle drilling machine

(7) Automatic drilling machine

(8) Deep-hole drilling machine

a) Vertical

b) Horizontal

Portable Drilling Machine

A portable drilling machine is a tiny, portable device used to drill holes in objects in any position that a normal drilling machine cannot. It may be used to drill tiny diameter holes directly into massive castings or weldment where they are laying. Small electric motors mounted on portable drilling machines can be powered by both an AC and a DC power source. These drilling machines can take drills up to 12 mm in diameter and run at reasonably high rates.

Sensitive Drilling Machine

It is a little tool used for quick, simple activities like drilling tiny holes. The workpiece is positioned on the table of this drilling machine, and the drill is fed into the work solely by manual control.The two main characteristics of a sensitive drilling machine are a high rotating speed of the drill and manual feed. It is referred to as a sensitive drilling machine because the operator may detect drilling activity in the workpiece at any time. A horizontal table, a vertical column, a head supporting the motor and drive mechanism, and a vertical spindle make up a sensitive drilling machine.The spindle of a sensitive drilling machine can rotate drills with a diameter of 1.5 to 15.5 mm. The following categories may be applied to the machine depending on how its base is mounted:

1. A bench-mounted drilling machine
2. A floor mounted drilling machine

Upright Drilling Machine

Compared to a sensitive drilling machine, the upright drilling machine is bigger and heavier. It comes with a power feed setup and is suited for handling medium-sized workpieces.

For drilling various types of work, this machine may offer a wide range of spindle speeds and feeds. There are many different sizes and drilling capacity for upright drilling machines, ranging up to 75 mm drills in diameter. The machine’s table can be adjusted in a variety of ways. There are generally two types of upright drilling machines based on construction:

1. A pillar drilling machine or round column segment.
2. Section in a box column two.

Unlike the upright drilling machine, which has a box column section, the upright drilling machine has a circular column. Other constructional characteristics are identical in both. Compared to machines with round section columns, box column machines are stronger and more robust.

Radial Drilling Machine

A machine for radial drilling is shown in Figure 2. The horizontal arm that carries the drill head is supported by a large, round vertical column in the radial drilling machine. On the column, the arm can be raised or lowered, rotated to any position over the work, and secured in any position. The drill head, which is positioned on a radial arm and contains the rotating and feeding mechanisms, can be moved horizontally along the guideways and clamped at any desired location. The operator is able to swiftly locate the drill over any place on the work thanks to these arm and drilling head modifications. Additionally, a radial drilling machine's table may revolve 360 degrees. The equipment can only drill holes up to a maximum diameter of 50 mm. Powerful drive motors are directly geared into the machine's head, and a variety of power feeds as well as delicate and geared manual feeds are offered. The radial drilling machine is mostly used to drill huge, heavy, and medium-sized workpieces. The following types of upright drilling machines can be categorised based on the various motions of the horizontal arm, table, and drill head:

A simple radial drilling device:

Drilling machines that are both semi-universal and universal are also available.

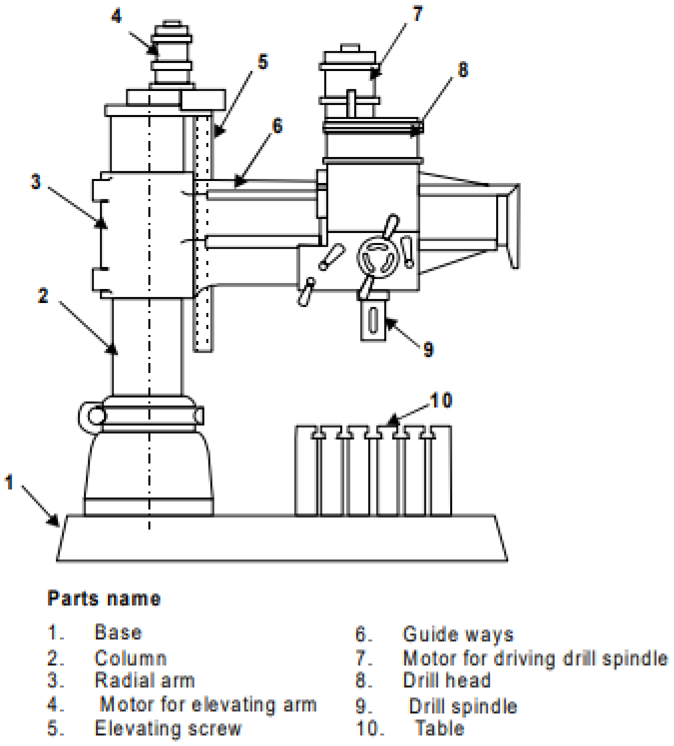

Figure 2: Shows radial drilling machine (wordpress.com)

In a plain radial drilling machine, provisions are made for following three movements –

1. Vertical movement of the arm on the column.
2. Horizontal movement of the drill head along the arm.
3. Circular movement of the arm in horizontal plane about the vertical column. In a semi universal drilling machine, in addition to the above three movements, the drill head can be swung about a horizontal axis perpendicular to the arm. In universal machine, an additional rotatory movement of the arm holding the drill head on a horizontal axis is also provided for enabling it to drill on a job at any angle.

Gang Drilling Machine

In a gang drilling machine, several single spindle drilling machine columns are arranged side by side on a shared base and have a shared worktable. By moving the work from one location on the worktable to another, a sequence of operations can be carried out on the project. The primary usage of this kind of machine is for production tasks.

Multiple-Spindle Drilling Machine

The usage of the multiple-spindle drilling machine allows for the simultaneous drilling of numerous holes in a job as well as the replication of the same pattern of holes in numerous identical items during mass production. This machine has multiple spindles, and concurrently, drills are fed into the work from each spindle that it holds. The worktable is typically raised to create a feeding action.

Types of Drill

A drill is a multi-point cutting tool used to produce or enlarge a hole in the workpiece. It usually consists of two cutting edges set an angle with the axis. Broadly there are three types of drills:

1. Flat drill,
2. Straight-fluted drill
3. Twist drill

Flat drill is usually made from a piece of round steel which is forged to shape and ground to size, then hardened and tempered. The cutting angle is usually 90 deg. And the relief or clearance at the cutting edge is 3 to 8 deg. The disadvantage of this type of drill is that each time the drill is ground the diameter is reduced. Twist drill is the most common type of drill in use today. The various types of twist drills (parallel shank type and Morse taper shank type) are shown in Figure 3.

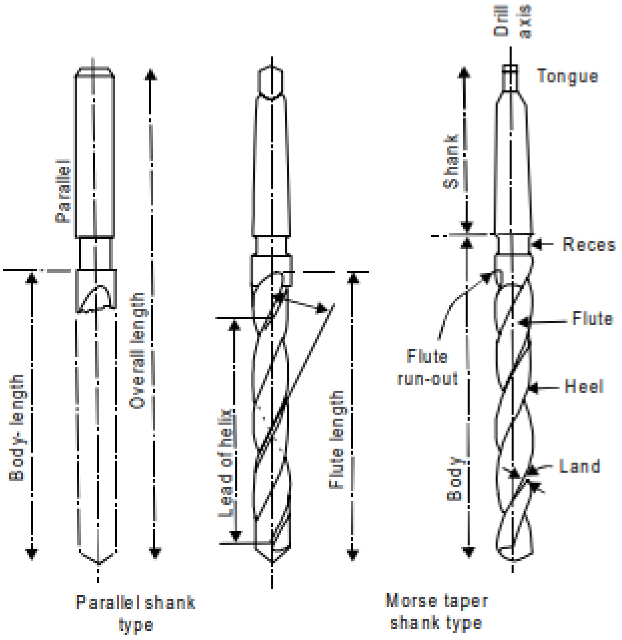

Figure 3: Shows types of twist drill(wordpress.com).

Twist Drill Geometry

Twist drill geometry and its nomenclature. A twist drill has three principal parts:

i. Drill point or dead center
ii. Body
iii. Hank

1. **Drill axis** is the longitudinal centre line.
2. **Drill point** is the drill body's sharpened end made up of all the parts that are formed to produce lips, faces, and chisel edges.
3. **Lip or cutting edge** is the edge formed by the intersection of the flank and face.
4. **Lip length** is the shortest distance between the lip's outer corner and its chiselled-edge corner.
5. **Face** is that portion of the flute surface adjacent to the lip on which the chip impinges as it is cut from the work.
6. **Chisel edge** is the edge created when the flanks collide.
7. **Flank**is that surface on a drill point which extends behind the lip to the following flute.
8. **Flutes** are the grooves on the drill's body that serve as lips, allow for chip removal, and allow cutting fluid to reach the lips.
9. **Flute length** is the distance along the axis between the point's extreme end and where the flutes finish at the body's shank end.
10. **Body** is the part of the drill name that goes from the very end of the cutting edge to the start of the shank.
11. **Shank** is the part of the drill that is used to hold and push the bit.
12. **Heel** is the edge created when the flute surface clearance crossand the body.
13. **Body clearance** is the area of the body surface that has a smaller diameter to allow for diametric clearance.
14. **Core or web** is the middle piece of the drill that extends from the point end towards the shank and is located between the roots of the flutes; the point end of the core creates the chisel edge.
15. **Lands** are the leading edges of the drill flutes' cylindrically ground surfaces. The width of the land is determined by measuring it perpendicular to the flute.
16. **Recess** is the area of the drill body that is designed to make it easier to grind the body, located between the flutes and the shank. Small diameter parallel shank drills are typically not equipped with a recess.
17. **Chisel edge** a comer is the corner created by the chisel edge and a lip interacting.
18. **Drill diameter**is the distance measured across the cylindrical lands at the drill's corners.
19. **Lead of Helix** is the distance measured between corresponding spots on the leading edge of a flute in one full turn of the flute, measured parallel to the drill axis.
20. **Helix angle** is the angle formed by the drill axis and the leading edge of the land.

21. **Rake angle** is the arc formed by the face and a line that is perpendicular to the drill axis. It is larger at the edges of the face and lowers to almost 0° in the drill's centre. As a result, the chip formation becomes increasingly unfavourable towards the core.

22. **Lip clearance angle** is often measured at the drills outside edge. It is the angle made up of the flank and a plane at right angles to the drill axis. The clearance faces slope backwards in a curving motion to ensure that the primary cutting edges can penetrate the material. The clearance angle, which is determined at the face edge and must range from 5° to 8°.

23. **Point angle** the angle that the cone's contained arc makes with the lips.

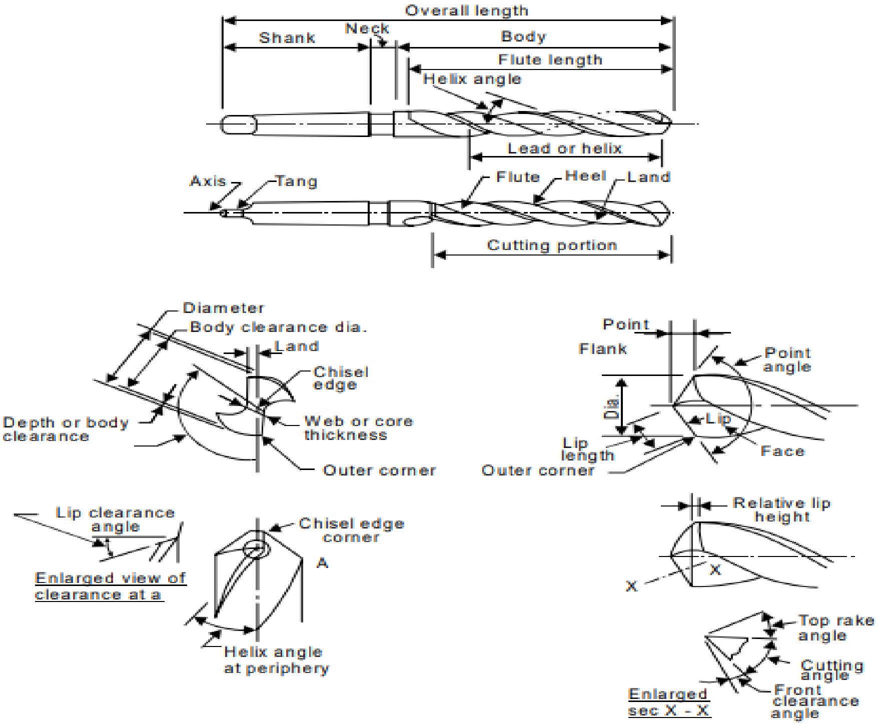

Figure4: Shows geometry and nomenclature of twist drill (wordpress.com).

Drill Material

High speed steel is used to make drills. About 90% of all twist drills are made of high-speed steel. HSS alloys from the high cobalt family are utilized for metals that are harder to cut[4]–[6].Figure 4 shows geometry and nomenclature of twist drill (wordpress.com).

Operations Performed on Drilling Machine

Drilling equipment is a flexible machine tool. On it, several operations can be carried out. Several tasks that drilling machines can carry out include:

1. Drilling
2. Reaming
3. Boring
4. Counter boring
5. Countersinking
6. Spot facing
7. Tapping
8. Lapping
9. Grinding
10. Trepanning

1. Drilling

In order to create a circular hole, a volume of metal must be removed from the work using a spinning cutting tool called a drill. To create a circular hole, drilling removes solid metal from the workpiece. A centre punch is used to create an indentation for the drill point at the centre to aid in starting the drill before the hole is located by drawing two lines at an angle. The drill machine is configured to work at the proper cutting speed while holding a suitable drill in place. As soon as the drill machine is turned on, the drill begins to rotate. The cut is initiated after freely distributing cutting fluid. It is designed for the rotating drill to feed into the task. Depending on how long the hole is, drilling may be done in one or more steps. The drill is removed from the hole once drilling is finished, and the power is then shut off.Figure 5 shows drilling operation (wordpress.com)

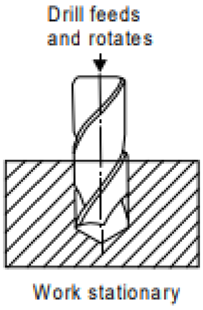

Figure 5: Shows drilling operation (wordpress.com).

2. Reaming

This process involves sizing and completing a hole that has already been drilled. Reaming is done with a reamer, a cutting instrument, as shown in Figure 6. The purpose of the reaming procedure is to make the hole smooth, straight, and accurately sized. A multitooth instrument called a reamer is used to perform reamming operations. A reamer is a tool with many cutting edges on the outside, and there are two types: solid reamers and adjustable reamers

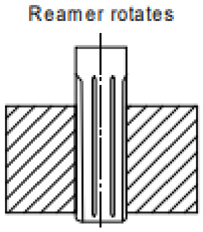

Figure 6: Shows reaming operation (wordpress.com).

3. Boring

The boring procedure, which enlarges a hole using adjustable cutting tools with only one cutting edge, is shown in Figure 7 in order to accomplish this, a boring tool is used.

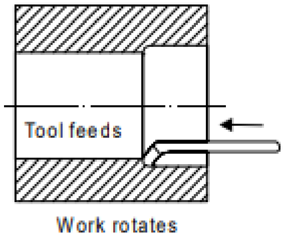

Figure 7: Shows boring operation (wordpress.com).

4. Counter-boring

In Figure 8, the counter boring process is displayed. It involves extending a hole's end cylindrically, such as to create a recess for a countersunk rivet. Counter-bore is the name of the tool.

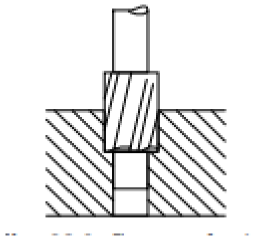

Figure 8: Shows counter-boring (wordpress.com)

5. Counter-striking

Figure 9 depicts the counter-sinking process. This procedure enlarges the end of a hole in a cone-shaped manner to provide a recess for a flat head screw. This is done to give countersunk screw heads a somewhere to sit so that they are flush with the work's main surface[7]–[9].

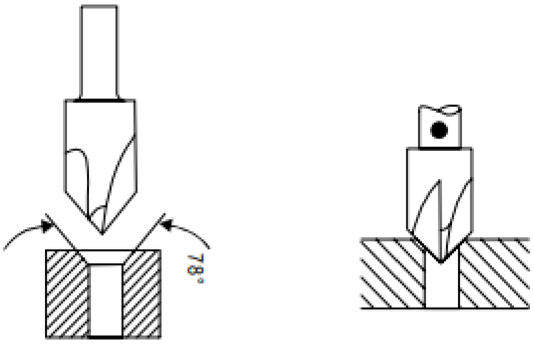

Figure 9: Shows counter-striking operation (wordpress.com).

CONCLUSION

Modern manufacturing and construction operations rely heavily on drilling machines because they provide variety, accuracy, and efficiency when drilling holes in workpieces. They are widely utilized in a variety of sectors, including the construction, automotive, woodworking, and metalworking industries.The adaptability of drilling machines is one of their main advantages. Bench drills, pillar drills, radial drills, and CNC (Computer Numerical Control) drilling machines are just a few of the several kinds of drilling equipment that are available. Each type has unique benefits and is appropriate for various applications and workpiece sizes. Drilling machines can be modified to meet a variety of needs, from small-scale drilling jobs to large-scale industrial operations.

REFERENCES

[1] M. J. Rahimdel, M. Ataei, and B. Ghodrati, “Modeling and Simulation Approaches for Reliability Analysis of Drilling Machines,” *J. Inst. Eng. Ser. C*, 2020, doi: 10.1007/s40032-019-00533-x.

[2] H. S. Al-Chalabi, J. Lundberg, A. Wijaya, and B. Ghodrati, “Downtime analysis of drilling machines and suggestions for improvements,” *J. Qual. Maint. Eng.*, 2014, doi: 10.1108/JQME-11-2012-0038.

[3] C. Robles-Algarín, W. Echavez, and A. Polo, “Printed circuit board drilling machine using recyclables,” *Electron.*, 2018, doi: 10.3390/electronics7100240.

[4] S. O. Banjo *et al.*, “Design and development of a table-mounted manual drilling machine for the rural purpose,” *IOP Conf. Ser. Mater. Sci. Eng.*, 2021, doi: 10.1088/1757-899x/1107/1/012168.

[5] M. J. Rahimdel, S. H. Hoseinie, and B. Ghodrati, “Ram analysis of rotary drilling machines,” *Min. Sci.*, 2016, doi: 10.5277/msc162307.

[6] J. Karliński, E. Rusiński, and T. Lewandowski, “New generation automated drilling machine for tunnelling and underground mining work,” *Autom. Constr.*, 2008, doi: 10.1016/j.autcon.2007.05.007.

[7] A. I. A. Shukor and A. Adam, “Evaluation of design efficiency using boothroyd dewhurst method for PCB drilling machine products,” *Int. J. Simul. Syst. Sci. Technol.*, 2018, doi: 10.5013/IJSSST.a.19.05.04.

[8] G. Jodh, P. Sirsat, N. Kakde, and S. Lutade, “Design of Low Cost CNC Drilling

Machine," *Int. J. Eng. Res. Gen. Sci.*, 2014.

[9] R. Klyuev, O. Fomenko, O. Gavrina, R. Turluev, and S. Marzoev, "Energy indicators of drilling machines and excavators in mountain territories," 2021. doi: 10.1007/978-3-030-57450-5_25.

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A BRIEF DESCRIPTION ON COLD WORKING

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ABSTRACT

In the metal forming process known as "cold working," a material is shaped and its mechanical properties are changed when the material is at ambient temperature or below its recrystallization temperature. The automobile, aerospace, and construction sectors all employ this method extensively. This study's goal is to give a general review of cold working, its methods, and how it affects the characteristics of the material. In this section, the various cold working techniques including rolling, forging, extrusion, and drawing—are examined, along with their uses and benefits. Analyses are also done on how cold working affects the material's microstructure, mechanical characteristics, and dimensional accuracy. The limitations and difficulties of cold working procedures are also examined, including the risk of cracking, lingering tensions, and decreased ductility.

KEYWORDS: *Cold Working, Die, Metal, Punch, Sheet, Wire.*

INTRODUCTION

A metal is subjected to cold working below its recrystallization temperature. Although different grades of steel are typically cold worked at room temperature, temperatures up to the recrystallization range are occasionally employed. Recovery when workings in the cold processes are inefficient.The most typical use of cold working is listed as purpose below.

1. Cold working is used to produce items with higher surface finishes.
2. It is frequently utilized in order to get improved mechanical qualities.
3. It is commonly used as a spinning and pressing forming technique for producing steel products.
4. It helps create thinner material.

Cold working should be avoided since it might cause cracks to grow and spread if done in excess. When the part is freed from the tooling and during further machining, residual stresses caused by inhomogeneous deformation induce warping or distortion. Therefore, the magnitude and distribution of residual stresses should be managed[1]–[3].On surfaces not impacted by tooling, orange-peel and stretcher strains are examples of roughness flaws due to the material. By employing fine-grained sheets, the former can be avoided, while the latter can be reduced by gently rolling or stretching the strip to stop localised yielding.

The following list includes the main characteristics of cold working.

1. Plastic deformation of a metal occurs during cold working, leading to strain hardening.

2. Cold working typically entails working at ambient temperature, but for metals with high melting points, like tungsten, it may be done at a red heat.
3. With the degree of distortion, the tension necessary for deformation increases quickly.
4. The quantity of deformation that can be carried out without adding additional treatment is constrained.
5. The grain structure is typically distorted during cold rolling.
6. Cold rolling produces a good surface polish.
7. The greatest temperature at which strain hardening is maintained is the upper temperature limit for cold working. Cold working causes strain hardening because it occurs below the recrystallization temperature.
8. Excessive cold working leads to the development and spread of metal fissures.
9. Cold working causes ductility to decrease, however this has a positive side effect for machining.
10. The chips break more easily and make the cutting process easier due to their decreased ductility.
11. Heating is occasionally necessary.
12. It is simple to impart directional features.
13. Cold-working procedures frequently experience spring back.
14. Cold working is frequently more cost-effective than hot working for metals that are reasonably ductile.

The cold worked part's qualities, which are listed below, both increase and decrease slightly.

Increased by the cold working process:

Ultimate tensile strength, yield strength, hardness, fatigue strength, and residual stresses are all important properties.

Cold working techniques reduce:

1. Percentage elongation.
2. Area reduction
3. Impact strength
4. Corrosion resistance
5. Ductility\

Limitations in Cold Working

1. Cold working results in less ductility.
2. Added directional features could be harmful.
3. There is strain hardening.
4. Prior to cold working, metal surfaces must be free of scale and clean.

5. To remove scale and other debris, hot wrought metal must be pickled in acid.
6. Deformation requires greater forces than those used in hot working.
7. Cold working calls for stronger and heavier equipment.

DISCUSSION

Advantages of Cold Working

1. Smooth surface finishes are simple to obtain in cold working procedures.
2. Parts' precise dimensions can be preserved.
3. The metal's ductility is reduced while its strength and hardness are boosted.
4. Because the job is done in a cold environment, no oxide would form on the surface, resulting in a superior surface finish.
5. The strain hardening that results from cold working makes a material stronger and harder, which is advantageous in some circumstances.
6. There is no chance that the surface will decarburize.
7. Greater dimensional precision is attained.
8. It is inexpensive for smaller sizes and much simpler to handle cold parts.

Disadvantages of Cold Working

1. Some brittle materials can be difficult to work with cold.
2. The capacity of the presses or hammers being utilized determines how much deformation may be supplied to the material because it has a higher yield strength at lower temperatures.
3. The grain structure becomes distorted.
4. Because of strain hardening, the material's maximum allowable deformation is constrained. After annealing, you can apply any additional deformation.
5. Internal tensions are created, and unless they are eliminated by appropriate heat treatment, they stay in the metal.

Cold Rolling

Hot rolling and cold rolling share a similar process setup. All types of bars, including rods, sheets, and strips, are frequently completed by rolling. In this method, foil is produced from the softer metals. Metals that have been cold-rolled give cold-rolled items a smooth, bright surface finish as well as good physical and mechanical qualities. Only light rolling will be required if the goal is to provide a clean, smooth finish for the metal. On the other hand, when it is desired to greatly improve the tensile strength and stiffness, the section thickness is significantly lowered, necessitating the use of higher roll pressures and deeper kneading. The quality of brittleness, which is advantageous to smooth tool finishes with fractured chips, is conferred by cold rolling, which also enhances the machinability of the cold rolled part. The pre-hot-rolled steel sheets are soaked in an acid solution to remove the washed-in water before being dried as the first stage in the cold-rolling process. The cleaned steel is run through a set of cold rolling rolls, slightly reducing each roll's thickness until the desired thickness is achieved[4]–[6].Known sometimes as a rolling stand, the configuration of rolls in a rolling mill varies depending on the use. Hot rolling and the numerous roll configurations are comparable. The names of the roll stand configurations are typically determined by the quantity of rolls used.Because a reversible drive is required, these stands are more expensive than non-reversible ones. In cold-rolled parts, internal tensions are created that stay in the metal until they are properly relieved through heat treatment. Compared to hot rolling, this procedure requires more power to complete the task.

Cold Extrusion

The difference is that material used in hot working procedures should have the necessary ductility even without heat being applied. Cold extrusion techniques include impact extrusion. It is applied to the production of tiny components made of ductile materials.

In Figure 1, the impact extrusion process is depicted. When the work blank is positioned above the die opening and a punch is used to force it through, the material is extruded by impact, flowing plastically all around the punch. The tube's thickness is determined by the space between the punch and die, whose outside diameter is the same as the tubes die diameter. Utilizing impact extrusion, collapsible toothpaste tubes and other medical supplies are created.

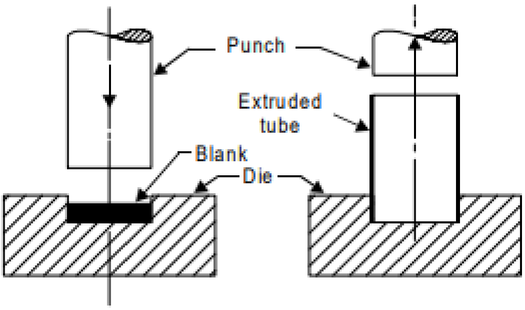

Figure 1: Shows impact extrusion (wordpress.com).

Wire Drawing

Pulling a wire through a hardened die, which is often composed of carbide, is how varied diameter wires are produced. However, a diamond-coated die is used to draw wires of a smaller diameter through. Prior to being lubricated, the bigger diameter oriented wire is cleaned, pickled, washed, and cleaned again. Cleaning is primarily done to get rid of any scale and rust that may be present on the surface and seriously harm the die. The typical method is acid pickling. Descaled, acid-pickled, water-washed, and coated with lime and other lubricants, hot-rolled steel undergoes these processes. The end of the stock has been pointed in order to make it simpler for wire to enter the die. The end of a wire that has been properly lubricated and pointed or reduced in diameter is pushed or introduced through a die that is also water cooled. Rotary swaging or straightforward hammering are also used for this aiming.After that, it is grabbed and pulled to be attached to a power-driven reel. Due to the material's ductility, the wire diameter is reduced in dies to a smaller diameter through a single set of dies. However, other sets of dies can be utilized in line for further reduction in diameter of the wire at each stage. For ductile materials like copper, the decrease in each pass through the die ranges from 10% to 40%.

Hot rolled steel rods or coils that are 0.8 to 1.6 mm larger than the ultimate size needed are used to begin drawing the wire. The wire is not pushed into the die from the entrance side with any force throughout this process. Given that it will be pushed by tensile forces, the material must be suitably ductile. Therefore, the wire might need to be thoroughly annealed to offer the required ductility. Additionally, the gripper is supposed to draw the wire out of the exit after passing it through the conical part. The cleaning of the wire and lubricating it as it passes through the die are the other necessary preparations. The lubrication of the die is a critical issue because of the enormous pressures that are present at the metal/die interface.

Therefore, certain processes like gulling, coppering, phosphating, and liming are utilized to transport the lubricant through the die. A tiny layer of ferrous hydroxide is applied to the wire, and when coupled with lime, it serves as a filler for the lubricant. This action is known as sulling. Phosphoring involves coating the wire with a thin layer of manganese, iron, or zinc phosphate. This causes the lubricant to adhere to the wire, lowering friction and, as a result, the drawing load. A lime-based coating is another lubricant used in wire drawing. Lime is added after acid pickling and left to dry. The lime adsorbs the lubricant needed to transport the acid to the die and neutralizes any acid that may have remained on the surface. The soap solution is typically used as a lubricant. Copper is electrolytically coated to reduce friction on very thin wires. High pressures and abrasion have a negative impact on the dies used for wire drawing. Chilled cast iron, tool steels, tungsten carbide, and diamond are some of the several die materials that are employed. For short runs, cast iron dies are utilized. Alloy steels are used to create the dies for very big sizes. For big productions and medium-sized wires, tungsten carbide dies are most frequently employed. Due to their extended lifespan, which is 2 to 3 times longer than that of alloy steel dies, tungsten carbide dies are frequently used. Diamond dies are used for wires that are incredibly fine. Because wire drawing is a cold process, the mechanical qualities are enhanced. The material loses ductility throughout the wire drawing process, thus interim annealing is necessary to restore it before the material is drawn again to reach the final size[7]–[9].Figure 1 shows Wire Drawing.

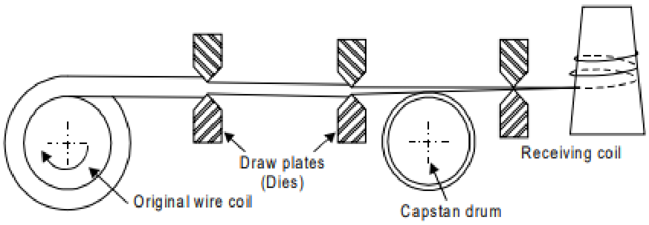

Figure 1: Shows Wire Drawing (wordpress.com)

Sheet Metal Processes

When making sheet metal components from sheet stock, sheet metal work processing is extremely frequent. On press machines with the necessary capacity, the various sheet metal operations are carried out using press tools or dies. The dies could be single- or multi-operational dies. However, the fundamental sheet metal procedures are explained in the lines that follow.Figure 2 Shows Typical Simple Press Tool.

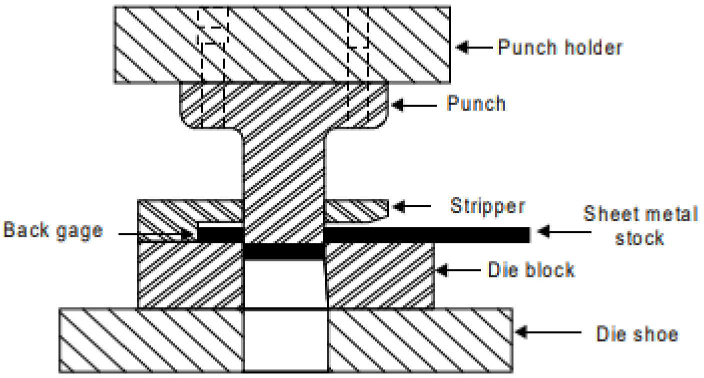

Figure 2: Shows Typical Simple Press Tool (wordpress.com).

General Sheet Metal Operations

Shearing

When punch and die are used, it happens. The space between the two shearing edges has a significant impact on the cut surface's quality. The next paragraphs, however, provide a description of the fundamental shearing procedures.

Cutting

It entails cutting a single line to separate a component from a strip.

Parting

It means that scrap has been eliminated in order to separate the two components.

Blanking

To ensure that the punch has enough metal to cut along its whole edge, it entails cutting a whole piece of sheet metal, leaving just enough scrap around the entrance. The blank portion, which has been separated from the strip, is led for additional processes. The last piece of metal strip is trash. Blanking is almost always the first operation, and it might be the only one required or it might be followed by numerous others in succession. Blanking is frequently integrated with additional processes in a single tool, allowing for one press stroke to complete the entire task. There must be clearance on a blanking die for the blank to fall freely and avoid becoming stuck in the die block.

Punching

It involves using a punch and die to create circular holes on a sheet of metal. The punched-out material is removed as trash. Contrarily, piercing is the technique of creating holes in any desired shape.

Notching

It is a procedure for cutting metal to the appropriate shape from a sheet or strip's side or edge.

Slitting

Slitting is the term used to describe the process of conducting shearing between rotary blades. The sheet metal is sliced longitudinally.

Nibbling

It is a process that uses standard tools to cut any shape out of sheet metal. It is carried out using a nibbling device.

Trimming

It is the process of removing extra metal from a piece that is in a flange or flash.

Lancing

A strip is cut partially across.

Forming

It is a method of dealing with metal in which the punch and die shapes are exactly duplicated in the metal with little to no metal flow.

Bending

It is used to bend various stock materials, such as sheets, rods, wires, bars, pipes, tubes, and different structural shapes, into the appropriate shapes. The items are bent using formed dies, and the process typically involves several steps. All sheet materials are overstressed during bending in both compression inside the curve and tension outside the bend. There is just one line, and that is the natural line, which stays the same length. The neutral axis is located between 30 and 50 percent of the thickness of the sheet away from the interior of the bend. The stock becomes thinner as the sheet metal on the outside is stretched. Angle bending, roll bending, roll forming, seaming, and spinning are all types of bending that are frequently referred to as "forming." In situations where mass bending of such components is necessary, well-designed fixtures are also utilized. When forces are applied to specific locations, like when bending a piece of metal into a right angle, bending occurs, while forming happens when whole things or individual portions are shaped.Figure 3 shows kinds of sheet metal bends using press brake dies.

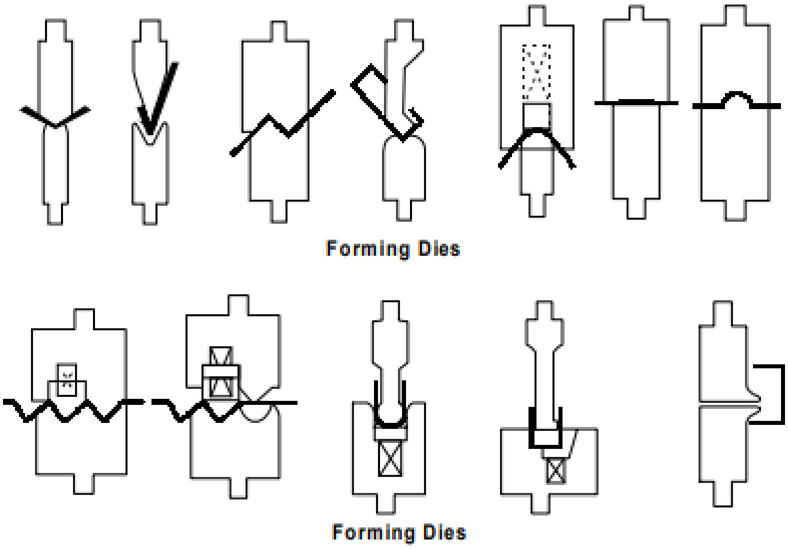

Fig. 3 shows kinds of sheet metal bends using press brake dies (wordpress.com).

Cold Drawing

Similar to hot drawing, it entails applying a tensile stress to the drawing die's exit side in order to force a metal through. The compressive force that results from the reaction of metal with die allows for the majority of the plastic flow. It is the process through which tensile stresses are used to cause the metal to flow plastically. The blank with the estimated diameter is put on a die and held there by a blank holder. The bottom of the blank is driven into the die by a punch, and the walls are pulled in, as shown in Figure 4. The effectiveness of an operation depends on a variety of factors, including the blank size, reduction factor, drawing pressure, blank holding pressure, punch and die diameters, type of lubricant, die material, etc. As a result, this method is typically used to create cup-shaped pieces from sheet blanks without too much wrinkling, thinning, or fracture. It can take on projects of almost any magnitude. Managing a flat, precut metal blank into a hollow vessel is what it entails. Stainless steel utensils are typically produced using this method[10], [11].

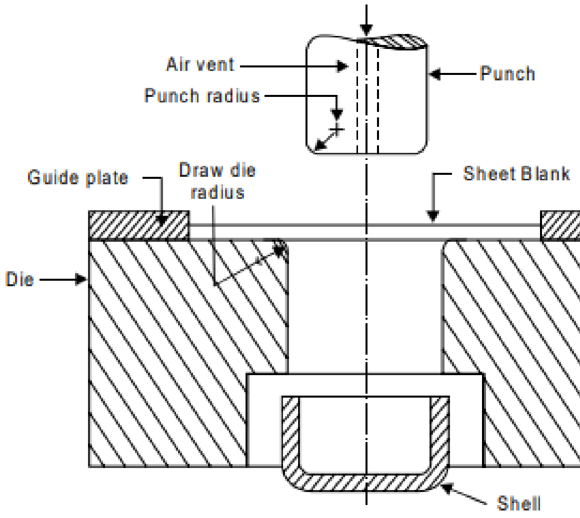

Figure 4: Illustrates Cold Drawing (wordpress.com).

Metal Flow in Deep Drawing Dies

Different forces come into play to generate a somewhat complex plastic flow of the material when the punch of a deep drawing press pushes a part of a metal blank into the bore of the drawing. The ultimate form of the cup will resemble the contour of the punch because the volume and thickness of the metal are virtually constant. Figure 5 shows Metal Flow in Deep DrawingThe metal flow can be summed up as follows.

a. No metal deformation occurs in the empty space that makes up the cup's bottom.

b. The volume elements' significant metal flow near the blank's edge involves a rise in metal thickness brought on by severe circumferential compression. The space between the punch and bore wall of the die ring limits the rise, thus it is often little.

c. As the cup is being formed, the metal flow will uniformly rise with cup height.

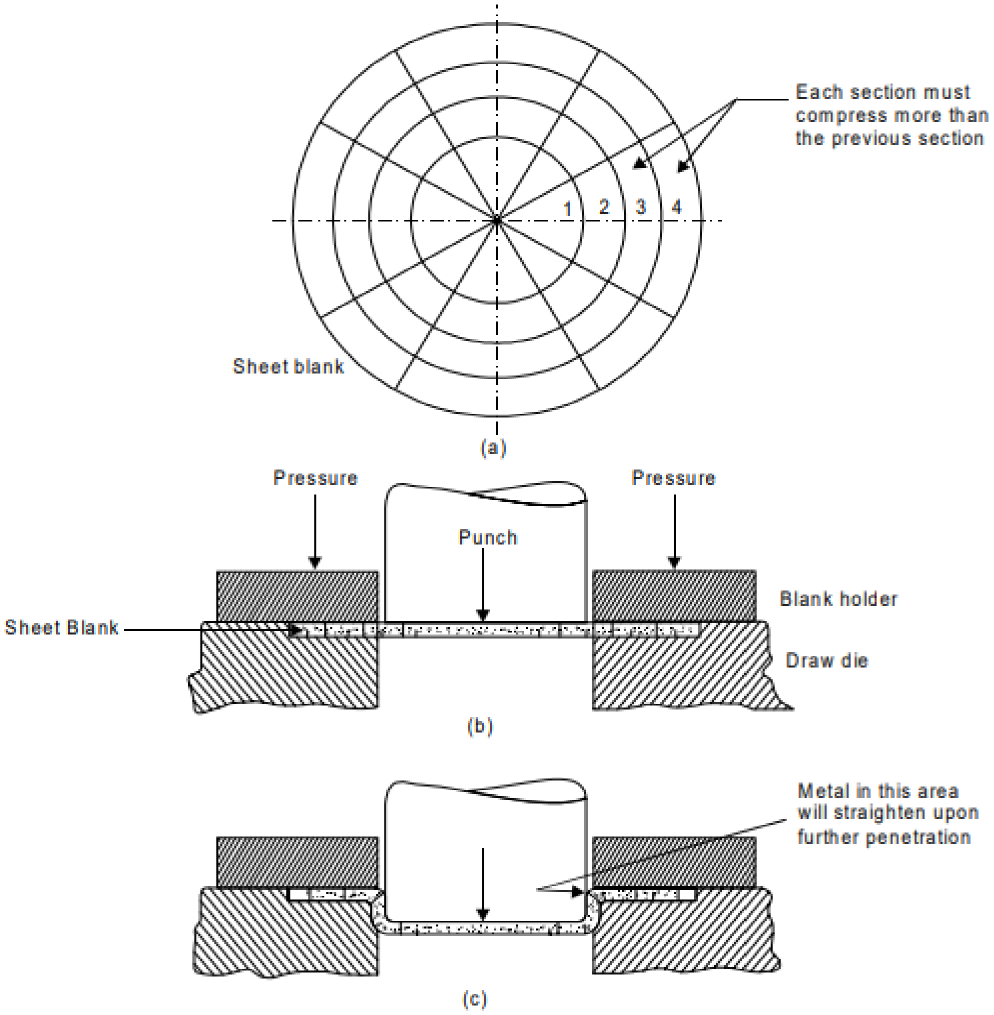

Figure 5: Shows Metal Flow in Deep Drawing (wordpress.com).

Embossing

The embossing procedure is depicted in Figure 6. Through the use of a punch and a die, sheet metal blanks are stretched under pressure into the desired shape. Punch moves at a slow pace to give the body time to stretch properly. The procedure causes the metal being embossed to harden. Deep parallel ridges can be created to lessen the material's stress. Metal plates and other ornamental goods in vast quantities are made. Open embossing is a straightforward variation of this technique that involves creating basic shallow shapes solely with a punch.

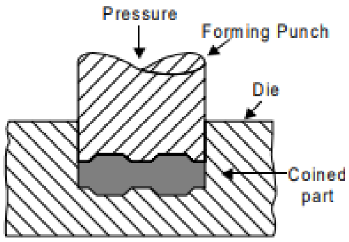

Figure 6: Shows Embossing (wordpress.com).

Coining

The coining procedure utilized in cold working procedures is depicted in Figure 7. Essentially, it is a cold working process that is carried out in dies where the metal blank is constrained and its lateral flow is constrained. It is mostly used to produce significant items with shallow configurations on their surfaces, such as medals, coins, stickers, and other such items. The process entails inserting a metal slug into the die and exerting significant punch pressure. Between the punch and the die, the metal flows plastically and is compressed into the desired shape. The procedure can only be used for soft metals with high plasticity due to the extremely high pressures needed.

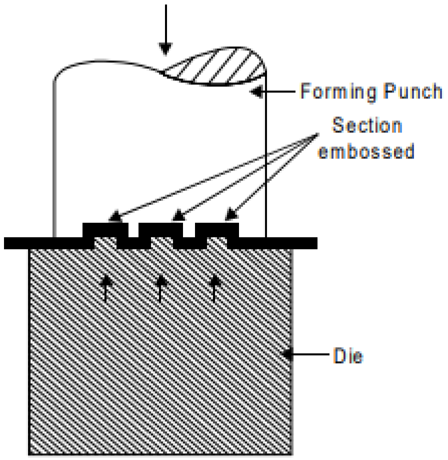

Figure 7: Shows Coining(wordpress.com).

Roll Forming

A continuous metal sheet or strip is fed through a set of rolls, where it is shaped into the necessary shapes. The roll formed parts can be used in their formed state with both of their edges apart. As an alternative, they can be welded together to create closed sections like pipes and tubes. The number of rolls used in the series varies depending on the shape that needs to be created. Additionally, the forming arrangement includes straightening tools and guide rolls.

Shot Peening

In this procedure, the surfaces of the parts are made harder and more fatigue resistant. The procedure entails spraying metal shot on a component's surface in order to shoot peen it. It is utilized to create a surface condition of surface compression stress, which causes the member's interior to take on an opposing tensile stress. Blast can be launched using either air pressure or a fast-revolving wheel. This metal shot is fired at a high velocity, creating a form of compression on the component's surface that increases the surface's hardness, strength, and fatigue resistance.

CONCLUSION

A useful method for improving the mechanical qualities of metals and alloys is cold working. Numerous advantages are provided, including enhanced strength, surface finish, and dimensional control. To avoid potential problems brought on by excessive deformation, the process variables and material choice must be carefully considered. To maximize the advantages and overcome the difficulties connected with this metal forming process, more research and development into cold working techniques, as well as their optimization, is required.

REFERENCES

[1] R. Allende-Seco, A. Artigas, H. Bruna, L. Carvajal, A. Monsalve, and M. F. Sklate-Boja, “Hardening by transformation and cold working in a hadfield steel cone crusher liner,” *Metals (Basel).*, 2021, doi: 10.3390/met11060961.

[2] R. K. Gupta, V. A. Kumar, C. Mathew, and G. S. Rao, “Strain hardening of Titanium alloy Ti6Al4V sheets with prior heat treatment and cold working,” *Mater. Sci. Eng. A*, 2016, doi: 10.1016/j.msea.2016.03.094.

[3] F. Cugini, L. Righi, L. van Eijck, E. Brück, and M. Solzi, “Cold working consequence on the magnetocaloric effect of Ni50Mn34In16 Heusler alloy,” *J. Alloys Compd.*, 2018, doi: 10.1016/j.jallcom.2018.03.293.

[4] M. Talha, C. K. Behera, and O. P. Sinha, “Effect of nitrogen and cold working on structural and mechanical behavior of Ni-free nitrogen containing austenitic stainless steels for biomedical applications,” *Mater. Sci. Eng. C*, 2015, doi: 10.1016/j.msec.2014.10.078.

[5] M. Inoue, T. Otsuka, K. Imae, and A. Azuma, “Retention characteristics of hydrogen in pure aluminum and duralumin with cold-working,” *Fusion Eng. Des.*, 2021, doi: 10.1016/j.fusengdes.2021.112711.

[6] H. Yang and H. Xue, “Effect of cold working on crack growth rate of environmentally assisted cracking of 316L SS,” *Structures*, 2020, doi: 10.1016/j.istruc.2020.09.006.

[7] S. Ueda, “Effect of Pre-cold-working on Diffusional Reversion of Deformation Induced Martensite in Metastable Austenitic Stainless Steel,” *ISIJ Int.*, 1994, doi: 10.2355/isijinternational.34.522.

[8] P. F. P. De Matos, P. M. G. P. Moreira, P. P. Camanho, and P. M. S. T. De Castro, “Numerical simulation of cold working of rivet holes,” *Finite Elem. Anal. Des.*, 2005, doi: 10.1016/j.finel.2005.01.001.

[9] Vipin Tandon and P. P. Awanikumar, “On the Influence of Cold Working and Electrochemical Nitridation on the Corrosion Behaviour of 316L Austenitic Stainless Steel in Acidic Environment,” *Surf. Eng. Appl. Electrochem.*, 2020, doi: 10.3103/S1068375520010147.

[10] M. Park *et al.*, “The effects of recrystallization on strength and impact toughness of cold-worked high-Mn austenitic steels,” *Metals (Basel).*, 2019, doi: 10.3390/met9090948.

[11] P. F. P. de Matos, A. J. McEvily, P. M. G. P. Moreira, and P. M. S. T. de Castro, “Analysis of the effect of cold-working of rivet holes on the fatigue life of an aluminum alloy,” *Int. J. Fatigue*, 2007, doi: 10.1016/j.ijfatigue.2006.04.004.

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VARIOUS TYPES OF FERROUS MATERIALS

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ABSTRACT

Ferrous materials, especially iron and its alloys, have been extensively employed in numerous sectors owing to their excellent characteristics, adaptability, and cost-effectiveness. This abstract presents an overview of ferrous materials, including their characteristics, uses, and current breakthroughs. Ferrous materials are noted for their tremendous strength, durability, and magnetic characteristics. Iron, the major component of ferrous materials, may be alloyed with carbon and other elements to generate a vast variety of materials with various properties. These alloys, including carbon steels and several kinds of cast irons, offer high mechanical qualities, great thermal conductivity, and strong corrosion resistance.

KEYWORDS: *Iron, Cast, Carbon, Pig, Strength, Furnace.*

INTRODUCTION

Engineering materials used to manufacture of objects or goods, determines which manufacturing process or processes are to be employed to offer it the required form. Sometimes, it is feasible to employ more than one manufacturing methods, then the best available process must be utilized in production of product them is thus vital to know what elements are available in the universe with them regular cost. What are the common features of engineering materials such as physical, chemical, mechanical, thermal, optical, electrical, and mechanical.

How they may be treated inexpensively to achieve the required result. The fundamental understanding of engineering materials and their characteristics is of tremendous value for a design and manufacturing engineer. The components of tools, machines and equipment's should be manufactured of such a material which has qualities suited for the circumstances of operation. In addition to this, a product designer, tool designer and design engineer should always be knowledgeable with many types of engineering materials, their qualities and applications to satisfy the functional requirements of the design product. They must comprehend all the impact which the production processes and heat treatment have on the qualities of the engineering materials[1]–[3].

Classification of Engineering Materials

A great numbers of engineering materials existing in the universe such as metals and non-metals (leather, rubber, asbestos, plastic, ceramics, organic polymers, composites and semiconductor). Leather is mainly used for shoes, belt drives, packaging, washers etc. It is highly flexible and can readily survive against severe wear under ideal circumstances. Rubber is often utilized as packaging material, belt drive as an electric insulator. Asbestos is basically employed for lagging round steam pipes and steam pipe and steam boilers since it is poor conductor of heat, thus prevents loss of heat to the surroundings. Engineering materials may also be classed into metals and alloys, ceramic materials, organic polymers, composites and semiconductors. The metal and alloys have vast applicability for manufacturing the items needed by the consumers.

Metals and alloys

Metals are polycrystalline substances comprised of a high number of fine crystals. Pure metals possess limited strength and do not have the needed characteristics. So, alloys are made by melting or sintering two or more metals or metals and a non-metal, together. Alloys may consist of two additional components. Metals and alloys are further categorized into two primary kind namely ferrous metals and non-ferrous metals.

a) Ferrous metals are those which contain the iron as their principal ingredient, such as pig iron, cast iron, wrought iron and steels.

b) Non-ferrous metals are those which contain a metal other than iron as its main constituent, such as copper, aluminum, brass, bronze, tin, silver zinc, invar etc.

Ferrous Metals

Ferrous metals are iron base metals which comprise every type of pig iron, cast iron wrought iron and steels. The ferrous metals are those which contain iron as their principal components. The ferrous metals widely utilized in engineering practice include cast iron, wrought iron, steel and alloy steels. The fundamental main raw material for all ferrous metals is pig iron which is obtained by smelting iron ore, coke and limestone, in the blast furnace[4]–[6].

DISCUSSION

Main Types of iron

1. Pig iron

2. Cast iron

(A) White cast iron

(B) Gray cast iron

(C) Malleable cast iron

(D) Ductile cast iron

(E) Meehanite cast iron

(F) Alloy cast iron

3. Wrought iron

4. Steel

(A) Plain carbon steels

1. Dead Carbon steels

2. Low Carbon steels

3. Medium Carbon steels

4. High Carbon steels

(B) Alloy steels

1. High speed steel
2. Stainless steel

Pig Iron

Pig iron was developed in the early days by reduction of iron ores in blast furnace and when the whole product of the blast furnace was sand cast into pigs which is a mass of iron roughly resembling a reclining pig. It is about of 20" × 9" × 4" in dimension. It is created in a blast furnace and is the initial product in the process of turning iron ore into useable ferrous metal.The iron ore on first refining and heating in blast furnace produces pig iron when the impurities are burned off in a blast furnace. Pig iron works as the raw material for production of all sorts of cast iron and steel goods. It is produced by smelting (chemical reduction of iron ore in the blast furnace. It is of tremendous relevance in the foundry and in steel making processes. It is partially refined in a cupola furnace that produces different grades of cast iron[7]–[9].

By puddling methods, wrought iron is created from pig iron. Steel is created from pig iron by several steel manufacturing procedures such as bessemer, open-hearth, oxygen, electric and spray steel production.Carbon resides in iron in free form (graphite) and/or in mixed form (cementite and pearlite). Pig iron is categorized on the basis of contents of free and mixed carbon as follows.

These divisions are often known as grades.

1. Grey pig iron (Grades 1, 2 and 3)

Grey pig iron comprises around 3% carbon in free form (i.e., graphite form) and roughly 1% carbon in mixed form. This is a soft form of pig iron.

2. White pig iron (Grades 4)

White pig iron is firm and robust. It includes virtually all of the carbon in the combined form.

3. Mottled pig iron (Grade 5)

This form of pig iron is in between the grey and white types. It has a medium hardness and molted look. The free and coupled forms of carbon occur in roughly equal proportion in mottled pig iron.

Cast Iron

Cast iron is simply an alloy of iron and carbon and is made by re-melting pig iron with coke, limestone and steel waste in a furnace known as cupola. The carbon percentage in cast iron varies from 1.7% to 6.67%. It also includes tiny levels of silicon, manganese, phosphorus and sulphur in form of impurity elements.

General properties of cast iron

Cast iron is exceedingly brittle and weak under tension and hence it cannot be utilised for making bolts and machine components which are subject to tension. Since the cast iron is a fragile material and so, it cannot be employed in those components of machines which are exposed to shocks.

It has cheap cost, good casting properties, strong compressive strength, great wear resistance and excellent machinability. These qualities make it a useful material for engineering purposes. Its tensile strength ranges from 100 to 200 MPa, compressive strength from 400 to 1000 MPa and shear strength is 120 MPa. The compressive strength of cast iron is much greater than the tensile strength. The carbon in cast iron is present either of the following two forms:

1. Free carbon or graphite.
2. Combined carbon or cementite.

The cast iron is categorised into seven primary varieties as follows:

(a) Grey cast iron

(b) White cast iron

(c) Mottled cast iron

(d) Malleable cast iron

(e) Nodular cast iron

(f) Meehanite cast iron

(g) Alloy cast iron and the chemical composition, extraction, characteristics and general uses of several forms of cast iron are addressed as under.

Grey Cast Iron

Grey cast iron is grey in color which is owing to the carbon being predominantly in the form of graphite (C in free form in iron). It contains: C = 2.5 to 3.8%.

Si = 1.1 to 2.8 %

Ferrous Materials 55 Mn = 0.4 to 1.0% P = less than 0.15%

S = less than 0.1% Fe = Remaining

It is made in cupola furnace by refining or pig iron.

Properties of Grey Cast Iron

(i) When shattered it yields grey color.

(ii) It can be readily cast.

(iii) It is characterised by presence of flakes of graphite in a matrix of ferrite and pearlite or austenite; graphite flakes occupy 10% of metal volume.

(iv) It can be readily machined and exhibits machinability better than steel.

(v) It exhibits lowest melting of ferrous alloys.

(vi) It has strong vibration damping capability.

(vii) It has strong resilience to wear.

(viii) It boasts excellent fluidity and consequently may be cast into intricate forms and thin sections.

(ix) It exhibits great compressive strength.

(x) It has a poor tensile strength.

(xi) It has extremely poor ductility and low impact strength as compared with steel.

Applications

The grey iron castings are typically used for machine tool bodies, automobile cylinder blocks, pipes and pipe fittings and agricultural tools. The additional applications involved are

(i) Machine tool constructions such as bed, frames, column etc.

(ii) Household appliances etc.

(iii) Gas or water pipelines for underground uses.

(iv) Man holes covers.

(v) Piston rings.

(vi) Rolling mill and general equipment components.

(vii) Cylinder blocks and heads for I.C. engines.

(viii) Frames of electric motor.

1. (ix)Ingot mold.

(ix) General machinery components.

(x) Sanitary wares.

(xi) Tunnel portion.

White Cast Iron

The white color is due to the fact that the carbon in this iron is in mixed form as iron carbide which is often characterised as cementite. It is the hardest component of iron. It is made in cupola furnace by refining or pig iron. The white cast iron may be made by casting against metal chills or by controlling analyses. The chills are employed when a hard and wear resistant surface is necessary for items such as for wheels, rollers crushing jaw, crusher plates. The chemical composition of white cast iron is provided as beneath.

C = 3.2 to 3.6% Si = 0.4 to 1.1 % Mg = 0.1 to 0.4% P = less than 0.3% S = less than 0.2% Fe = Remaining.

Properties

(i) Its name is owing to the fact that its newly shattered surface exhibits a dazzling white fracture.

(ii) It is highly hard owing to carbon chemically linked with iron as iron carbide (Fe3C), which is brittle as well.

(iii) It exhibits good abrasive wear resistance.

(iv) Since it is incredibly hard, hence it is very tough to machine.

(v) Its solidification range is 2650-2065°F.

(vi) Shrinkage is 1/8 inch per foot.

(vii) The white cast iron has a high tensile strength and a low compression strength.

Applications

(i) For making malleable iron castings.

(ii) For producing those component or components which need a hard, and abrasion resistant surface such as rim of automobiles.

(iii) Railway brake blocks.

Ductile Cast Iron

When modest amounts of magnesium or cerium is added to cast iron, then graphite content is changed into nodular or spheroidal form and it is well spread throughout the material. The final structure contains qualities more like cast steel than like the other grades of cast iron. Graphite is in spheroidal shape instead than in flaky form. Its structure may be varied by alloys or heat treatment, as in steel to generate austenite, acicular, martensite, pearlite, and ferrite structure.Silicon is also employed as an alloying element as it has no influence on size and distribution of carbon content. The magnesium influences the production of graphite. But it has minimal influence on the matrix structure. Nickel and manganese give strength and ductility. Ductile cast iron has great fluidity, outstanding castability, strength, high toughness, excellent wear resistance, pressure tightness, weldability and better machinability in contrast to grey cast iron.

Malleable Cast Iron

The common cast iron is quite hard and brittle. Malleable cast iron is inappropriate for articles which are thin, light and susceptible to stress. It may be flattened under pressure by forging and rolling. It is an alloy in which all mixed carbon transformed to free form by suitable heat treatment. Graphite initially exists in iron in the form of flakes which is the source of weakness and brittleness. Carbon in this cast iron is scattered as small specks instead of being flaky or in mixed form. The small particles have not such weakening impact and casting would not shatter when dropped. The tensile strength of this cast iron is generally higher than that of grey cast iron. It has excellent machining quality and is used for making machine parts for which the steel forging and in which the metal should have a fair degree of machining accuracy e.g., hubs of wagon, heels small fittings for railway rolling brake supports, parts of agricultural machinery, pipe fittings, hinges, locks etc.

It may be produced by annealing the castings. The cast iron castings are packed in an oxidizing substance such as iron ore or in an inert material such as crushed fire clay depends upon the procedure employed either white heart or black heart. The packed casting is placed into an oven and is heated approximately 900°C temperature and is held at that temperature for about two days and it is then allowed to cool gently in the furnace itself. Iron ore acting as an oxidizing agent interacts with C and CO2 escape. Thus annealed cast result is free from carbon. If the castings are encased in an inert substance then gradual cooling will separate out the combined carbon to temper carbon. To generate malleable casting, initial casting is prepared which has all mixed carbon. The resultant castings are subsequently heat-treated in a specific way according to white heart technique or black heart method.

White Heart Malleable Iron Casting

The castings taken out of the mould are placed into a drum with sand and powdered slag.The drum is then closed and maintained in the air furnace and it is increased to highly temperature slowly. The temperature is increased to 920°C in two days time, held at this degree for nearly up to 50 to 80 hours then the drum is allowed to cool in the furnace (usually air furnaces) at the rate 5 to 10°C per hour until it arrives to room temperature. The complete cycle takes around one weak. During this process combined carbon separates apart and all the carbon does not convert into graphite state but change in other form of free carbon called tempered carbon.

$Fe_3C \longrightarrow 3Fe + C$

This makes the casting less brittle and bendable. The fracture part of such a casting is dark grey or black in color. These castings are mainly employed in car industries.

Black Heart Malleable Iron Casting

The castings put in a drum of oxidizing medium which is commonly powdered iron ore or powered scale (film of Fe_3O_4 on surface). This close drum is maintained in the furnace and heated to 900°C. It is then kept at this temperature until about 40 to 70 hours and allowed to cool slowly in a furnace itself. The castings become pliable like white heart cast iron. The percentage of carbon and silicon should be so determined that it may stimulate the development of free carbon when these castings are annealed.

Meehanite Cast Iron

Meehanite cast iron is an infected iron of a specifically manufactured white cast iron. The composition of this cast iron is graphitized in the ladle using calcium silicide. There are various types of meehanite cast iron notably heat resistant, wear resisting and corrosion resisting kind. These materials have great strength, toughness, ductility and good machinability. It is highly suitable for manufacturing castings demanding high temperature applications.

Alloy Cast Iron

The cast irons as stated above include minor quantities of additional components like silicon, manganese, sulphur and phosphorus. These cast irons may be described as ordinary cast irons. The alloy cast iron is formed by adding alloying elements like nickel, chromium, molybdenum, copper and manganese in adequate proportions in the molten metal collected in ladles from cupola furnace. These alloying elements offer increased strength and result in improvement of characteristics. The alloy cast iron has particular qualities like improved strength, high wear resistance, corrosion resistance or heat resistance. The alloy cast irons are extensively utilised for vehicle components such cylinders, pistons, piston rings, crank cases, brake drums, parts of .crushing and grinding machines etc.

Effects of impurities on cast iron

The cast iron includes minor quantities of carbon, silicon, sulphur, manganese and phosphorus. The impact of these impurities on the cast iron are as follows:

1) **Carbon:** Carbon is one of the main ingredients in cast iron. It decreases melting point of iron. Pure iron has a melting temperature of around 1500°C whereas iron with 3.50% C has melting point of about 1350°C. When carbon is in free form i.e. as graphite form the resultant cast iron is termed grey cast iron. On the other hand, when the iron and carbon are chemically combined form of cementite, the cast iron will be hard and known as white cast iron.

2) **Silicon:** Presence of silicon in cast iron facilitates the breakdown of cementite into graphite. It also helps to lessen the shrinkage in cast iron when carbon is changed to graphite forms.
3) **Sulphur:** It makes the cast iron hard and brittle. Since too much sulphur gives unsound casting, however, it should be maintained below 0.1% for most casting applications.It is generally accountable for producing issues to foundry personnel. It will make cast iron hard so counteracting the softening affects of silicon. It reduces strength and promotes brittleness. It also increases oxidation of cast iron. Hence, it is kept as low as feasible in cast iron.
4) **Manganese:** It renders cast iron white and hard. It is frequently maintained below 0.75%. It helps to exert a regulating impact on the detrimental effect of sulphur. It reduces the negative effects of the sulphur by generating the manganese sulphide which is not soluble in cast iron.
5) **Phosphorus:** It promotes fusibility and fluidity in cast iron but produces brittleness.

It is seldom permitted to reach 1 %. Phosphorus in irons is beneficial for casting of intricate designs and for manufacturing extremely inexpensive and light technical castings.Phosphorus has no influence on the carbon as well as on shrinkage in the cast iron.

Wrought Iron

Wrought iron is the considered generally the purest iron which has at least 99.5% iron. It has a significant number of minute threads of slag laying parallel to one other, thereby giving the metal a fibrous look when split. It is stated as a mechanical mixing of very pure iron and a silicate slag. It may alternatively be characterized as a ferrous substance, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which a minutely and uniformly distributed amount of slag is integrated without subsequent fusing. This iron is produced from pig iron by re-melting it in the puddling furnace or air furnace or reverberatory furnace. The molten metal free from impurities is withdrawn from the furnace as a pasty mass of iron and slag. The balls of this pasty mass, each around 45 to 65 kg in weight, are created.These balls are then mechanically manipulated to squeeze out the slag and to mould it into some commercial shape. This iron has nearly no carbon and so cannot be toughened.

Properties

The wrought iron may be readily formed by hammering, pressing, forging, etc. It is never cast and it may be readily bent while cold. It is robust and it has high ductility and plasticity with which it can be forged and welded readily. Its final strength may be boosted considerably by cold working followed by a period of age. It has a great resistance against corrosion.

It can accept unexpected and high shocks loads without lasting harm. It has a high resilience against tiredness. Its maximum tensile strength is 2,500 kg/cm2 to 5,000 kg/cm2 and the ultimate compressive strength is 3,000 kg/cm2. It may be stretched greatly by cold working. It has strong electrical conductivity. The melting point of wrought iron is about 1530°C. It possesses elongation 20% in 200 mm in longitudinal direction and 2–5 % in transverse direction. Its poison’s ratio is 0.30. It can be readily made while cold, without the outer side cracking at the created area.

Applications

It is used for producing chains, crane hooks, railway couplings, and water and steam pipelines.It has application in the form of plates, sheets, bars, structural works, forging blooms and billets, rivets, and a wide range of tubular products including pipe, tubing and casing, electrical conduit, cold drawn tubing, nipples and welding fittings, bridge railings, blast plates, drainage lines and troughs, sewer outfall lines, weir plates, sludge tanks and lines, condenser tubes, unfired heat exchangers, acid and alkali process lines, skimmer bars, diesel exhaust and air brake piping, gas collection hoods, coal equipment, cooling tower and spray pond piping[10], [11].

CONCLUSION

Ferrous materials, particularly iron and its alloys, continue to play a significant role in numerous sectors owing to their excellent characteristics, adaptability, and cost-effectiveness. These materials display great strength, durability, and magnetic characteristics, making them appropriate for a broad variety of applications.Carbon steels, stainless steels, and cast irons are examples of ferrous alloys that provide distinct benefits in terms of mechanical qualities, corrosion resistance, and thermal conductivity. They are widely utilized in construction, automotive, manufacturing, architecture, and many other sectors.

REFERENCES

[1] J. Wang, G. Zhang, N. Chen, M. Zhou, and Y. Chen, "A review of tool wear mechanism and suppression method in diamond turning of ferrous materials," *International Journal of Advanced Manufacturing Technology*. 2021. doi: 10.1007/s00170-021-06700-8.

[2] L. Zou, Y. Huang, M. Zhou, and G. Xiao, "Thermochemical wear of single crystal diamond catalyzed by ferrous materials at elevated temperature," *Crystals*, 2017, doi: 10.3390/cryst7040116.

[3] G. D. Gautam and A. K. Pandey, "Pulsed Nd:YAG laser beam drilling: A review," *Optics and Laser Technology*. 2018. doi: 10.1016/j.optlastec.2017.09.054.

[4] M. Łępicka and M. Grądzka-Dahlke, "Direct current and pulsed direct current plasma nitriding of ferrous materials a critical review," *Acta Mech. Autom.*, 2016, doi: 10.1515/ama-2016-0024.

[5] F. Brownlie *et al.*, "Effect of cathodic protection methods on ferrous engineering materials under corrosive wear conditions," *Corros. Eng. Sci. Technol.*, 2020, doi: 10.1080/1478422X.2020.1742997.

[6] E. K. Arthur and S. T. Azeko, "Surface hardening of ferrous materials with cassava (Manihot spp.) waste: A review," *Scientific African*. 2020. doi: 10.1016/j.sciaf.2020.e00483.

[7] P. Xu, X. Zhou, and Q. Liu, "Tribochemical machining of polycrystalline diamond using ferrous tool materials," *Mach. Sci. Technol.*, 2020, doi: 10.1080/10910344.2019.1636262.

[8] A. Nath, S. V. Barai, and K. K. Ray, "Prediction of asymmetric cyclic-plastic behaviour for cyclically stable non-ferrous materials," *Fatigue Fract. Eng. Mater. Struct.*, 2019, doi: 10.1111/ffe.13124.

[9] A. Inada, H. Ohmori, S. Min, and D. Dornfeld, “Investigation of the effects of an electrolytic coolant with a nano carbon additive in diamond micro cutting on ferrous materials,” *J. Adv. Mech. Des. Syst. Manuf.*, 2010, doi: 10.1299/jamdsm.4.1076.

[10] G. B. Olson, “Genomic materials design: The ferrous frontier,” *Acta Mater.*, 2013, doi: 10.1016/j.actamat.2012.10.045.

[11] US EPA, “Ferrous Metals: Material-Specific Data,” *Facts and Figures about Materials, Waste and Recycling*, 2021.

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EXPLANATION OF FITTING PROCESS

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ABSTRACT

By assembling, lining up, and connecting diverse components, fitting plays a critical part in the production processes, resulting in reliable and useful products. This abstract gives a general review of fitting in manufacturing, emphasizing its significance, methods, resources, and difficulties. In order to ensure optimal operation, structural integrity, and dimensional accuracy of completed items, it emphasizes the need of fitting. The abstract also covers developments in fitting, including CAD software, accurate measurement equipment, and automated assembly methods, which have increased effectiveness, productivity, and quality. In conclusion, this abstract provides a general overview of the crucial component of fitting in the industrial sector.

KEYWORDS: *Gauge, Marking, Measuring, Surface, Steel, Tools.*

INTRODUCTION

Automatic machines are used in small, medium, and large enterprises nowadays. However, bench and fitting work is equally important for completing a project with the appropriate accuracy. Through a variety of rapid machining procedures, the majority of semi-finished works can be completed with a respectable level of accuracy and in a reasonable amount of time. To complete the task by hand, they still need to conduct a few minor tasks. The process of producing an item by hand on a bench is referred to as bench work. While fitting, which may or may not be done at the bench, is the assembly of parts and the removal of metals to ensure the appropriate fit. In order to complete these two forms of work to the proper shape and size, a significant number of hand tools and other equipment must be used[1]–[3].

Tools used in Fitting Shop

1. Marking tools
2. Measuring devices
3. Measuring instruments
4. Supporting tools
5. Holding tools
6. Striking tools
7. Cutting tools
8. Tightening tools
9. Miscellaneous tools

1. Marking tools

These are further divided into the following categories: surface gauge, scriber, semi-circular protractor, prick punch, center punch, try square, bevel square, steel rule, circumferential rule, straight edge, flat steel square, scriber, and trammel.

2. Measuring devices

In bench and fitting shops, measurement tools and equipment such fillet and radius gauges, screw pitch gauges, surface plates, try squares, dial gauges, feeler gauges, plate gauges, and wire gauges are frequently used.

3. Measuring Instruments

Equipment for measuring the ends of lines. When utilizing a line measuring equipment, such as steel rules or scales, the ends of the dimension being measured are aligned with the graduations of the scale from which the length is read directly. In contrast, using an end measurement instrument.In devices like a gauge block, Vernier calipers, and micrometers, etc., the measurement is done between two ends. End measuring tools are frequently used to measure component dimensions precisely and accurately. Different measuring tools are used to determine angular or geometric measurements, while others are used to measure linear dimensions. A few measurement devices are also stored for reference and as benchmarks for comparison[4]–[6].

(i) Linear measurements

(a) Non-precision instruments

1. Calipers
2. Divider
3. Telescopic gauge
4. Depth gauge
5. Steel rule

(b)Precision instruments

1. Micrometer
2. Vernier caliper
3. Vernier depth gauge
4. Vernier height gauge
5. Slip gauge

(ii) Angular measurements

(a) Non-precision instruments

1. Protector
2. Engineer square
3. Adjustable set

4. Combination set

(b) Precision instruments

1. Bevel protector
2. Angle gauge
3. Sine Bar
4. Clinometer
5. Autocollimator
6. Spirit level

(iii) Surface instruments

1. Straight edge
2. Surface gauge
3. Surface table
4. Optical Flat
5. Profilo-meter

4. Supporting Tools

V-block, marking table, surface plate, and angle plate are among them.

5. Holding Tools

These are clamps and vices. Different vices are employed for various objectives. They consist of a pin vice, hand vice, bench vice, and leg vice. Additionally, there are other varieties of clamps, including the plane slot, gooseneck, double end finger, u-clamp, parallel jaw, and clamping block.

6. Striking Tools

There are many different kinds of hammers, including ball peen, straight peen, cross peen, double face, and soft face hammers.

7. Cutting Tools

Various sorts of files, scrapers, chisels, drills, reamers, taps, snipers, shears, and hacksaws are used for these.

FilesA file can be flat, square, circular, triangular, knife-shaped, pillar-shaped, needle-shaped, or any combination of these.

ScrapersThese come in half-round, flat, hook, and triangle shapes.

ChiselsFitting work involves the use of many chisel types, including flat, cross-cut, diamond-point, half-round, cow-mouth, and side-cutting chisels. Drills, reamers, taps, snips, hacksaws (both manual and power hacksaws), and other cutting instruments are also available.

8. Tightening Tools

These are the sub-classified items known as pliers and wrenches.

PliersOrdinary, needle-nose, and special types are these.

WrenchThese include box wrenches, pipe wrenches, Allen wrenches, offset sockets, open single ended, open double ended, closed ended adjustable, and ring spanners.

9. Miscellaneous Tools

These include a drill press, a spot facing bit, a counter sink tool, a counter boring tool and a die.

Measuring Tools

1. Steel Rule

In order to measure and set out preliminary proportions, steel rules are typically used. The 1 cm point is always a good place to start measuring from because the rule's end is usually worn out.

2. Circumference Rule

It is frequently used as a straight edge, for laying out, and for measuring. This rule is unique in that it allows for the direct measurement of circumference beneath the diameter dimension.

3. Straight Edges

Straight edges come in two different varieties: four-edge type both of which are constructed of alloy and carbon tool steel. They typically consist of steel flat graded bars with one longitudinal edge beveled. Straight edges often range in length from 2.5 mm to one meter and beyond. They are primarily utilized for drawing lengthy, straight lines [7]–[9].Figure 1 shows Straight edges

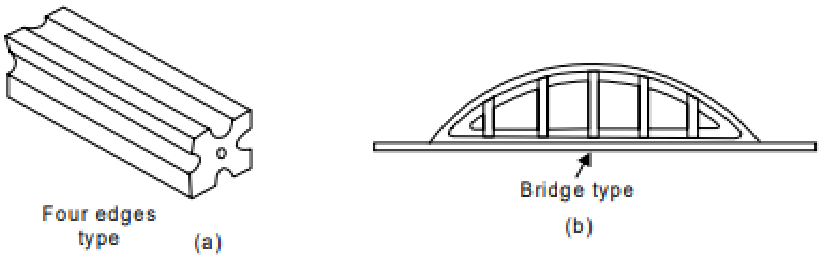


Figure 1: Shows Straight edges (wordpress.com).

4. Flat Steel Square

It consists of a flat piece of hardened steel with graduations on both ends. It is frequently used to identify lines that run perpendicular to any base line.

5. Scriber

The different varieties of scribers, often known as the metal worker's pencil these are manufactured of high carbon steel and have a front edge hardening process. When laying out a work, a scriber is used to scratch lines onto the sheet metal.Figure 2 shows scribers.

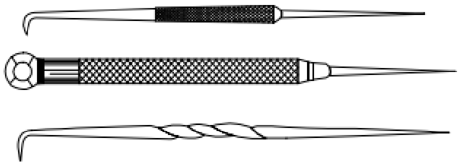


Figure2: Shows Scribers (wordpress.com).

6. Bevel Protector

A tool for testing and measuring angles with a five-minute accuracy limit is the bevel protector. This instrument's base and disc, which has a pivot in the middle and bears a datum line, are its common parts. When the clamping nut is loosened, the dial is permitted to spin on this protective pivot. The other device firmly secures the blade to the dial. One can rotate the blade longitudinally. On the disc, there is a Vernier scale that can be used to take readings for precise measurement. Degrees are graduated over an arc on the dial.Figure 3 shows Bevel Protector.

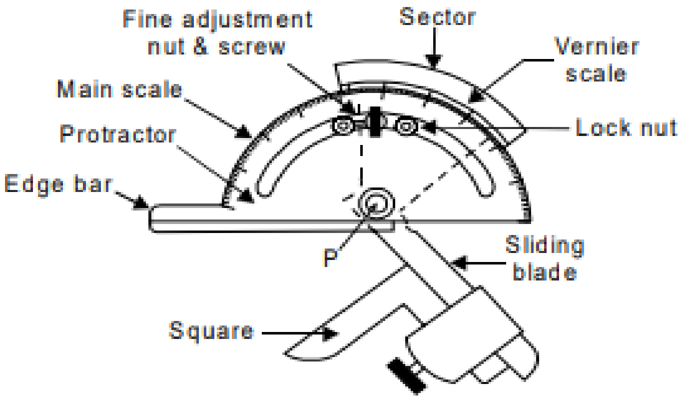


Figure 3: Shows Bevel Protector (wordpress.com).

7. Divider

On sheet metal, it is employed for marking and drawing circles and arcs.

8. Trammel

For marking and drawing enormous circles or arcs that are outside the capabilities of dividers, use a trammel.

Surface Gauge

It comes in a variety of shapes and sizes. It comprises of a vertical steel rod attached to a cast iron sliding base. A knurled nut on one end of the scriber or marker is used to place or set it into an adjustable device. By using the nut, you can tighten or loosen the scriber. The marker is used to move the object about inside the hole that accommodates it, put it at any desired slant, or change its height along the vertical pillar.

It frequently goes with either a surface plate or a marking table. Using a proper tool, such as an angle plate, it is used to describe straight lines on work that is firmly held in place as well as to draw a number of lines parallel to a true surface. It is also used to locate the centers of round rods held in V-blocks. This is a relatively basic surface gauge, and the universal surface gauge is mostly taking its place as a more precise tool.Figure 4 shows a surface gauge or scribbling block.

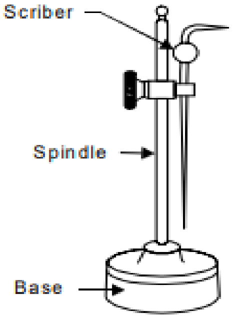


Figure 4: Shows a surface gauge or scribbling block (wordpress.com).

Universal Gauge

Its layout makes it possible to make noticeable finer tweaks rapidly.It is made out of a cast foundation that has been flawlessly machined and honed on all sides. In order to make the gauge acceptable for usage on rounded objects, the base of the gauge typically has a V-shaped groove at the bottom. At the back of the base, there are two guiding pins that can be depressed to extend below the gauge's base. These pins can also be used to guide the tool while marking and scribing on the edge of a surface plate or any other completed surface. At the top of the base, where the spindle is mounted, is a swivel bolt. By using the adjustment screw, which has a knurled nut at one end for this purpose, the spindle can be swung and secured in any desired position.

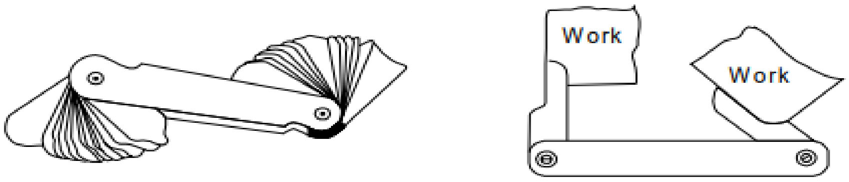
The scriber is attached to an adjustable screw on the spindle for marking purposes and can be set at any angle and height along the spindle. At the top of the base, there is a rocker with an adjustment screw at the back. The spindle is fixed in the swivel bolt and adjusted to the proper inclination during use. The adjustable scriber is rotated and positioned roughly at the necessary height. Finer adjustments are then done using the adjusting screw that is provided on the rocker after positioning the scriber's tip at the precise proper height. As a result, this gauge is frequently used for marking parallel lines at desired heights from a flat surface, determining whether two heights are true, laying out a desired height, and performing similar additional tasks, making it a crucial tool for bench work.

Measuring Devices

There are some general-purpose measuring tools, including a surface plate, a try square, a fillet and radius gauge, and a screw pitch gauge.

Fillet and Radius gauge

Concave end faces are present on one pair of blades fixed on one end of the case, while convex end faces are present on the other set of blades mounted on the opposite end of the case. Because the radii of the end forms' curvatures are of various dimensions, there is a sizable range for quickly testing and measuring curvature. Figure. 5 shows fillet and radius gauge and its use.The interior and outside radii of fillets and other round surfaces can be measured and checked with this tool. The fillet and radius gauges are constructed from strong, thin strips that are curled to various radii at one end.



A fillet and radius gauge **Use of fillet and radius gauge**

Figure 5 shows fillet and radius gauge and its use (wordpress.com).

Screw Pitch Gauge

It consists of a metal case holding several blades or threaded strips with teeth of various pitches cut into their edges and surface marks corresponding to these pitches. When a blade meshes with the cut teeth, the relevant reading is directly read from the marking on the corresponding blade surface. During operation, several blades are applied to or tried on the threads one at a time. For measuring or verifying the pitches of both external and internal threads, this gauge is frequently employed. The screw pitch gauge blades' free ends are typically made small so they can easily enter hollow objects to examine the internal threads. Some instruments contain markings on the blades for the pitches as well as a value that is equal to twice the depth of the threads. The latter quantity makes it easier to decide immediately what size drill to use before tapping.

Surface Plate

Grinding and scraping are used to finish the plate's top surface to perfection. It has a cast iron foundation that is likewise accurately machined to maintain the plate's top surface in a perfect horizontal plane.Figure 7 shows use of surface plate and V-block Its specialized applications include scribing work, inspecting finished surfaces for accuracy, checking try squares, and providing suitable bearing surfaces for V-block and angle plates[10], [11].Figure 6 shows surface plate.

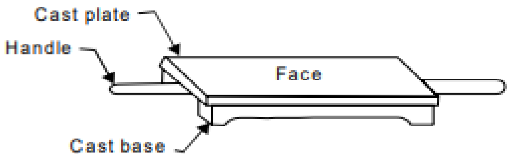


Figure 6: Shows surface plate (wordpress.com).

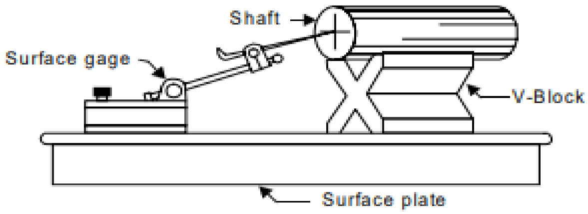


Figure 7: Shows use of surface plate and V-block (wordpress.com).

CONCLUSION

Fitting is a crucial step in the manufacturing process that involves putting parts together and connecting them to make durable and reliable products. Fitting ensures accurate alignment, dimensional accuracy, and structural integrity, all of which contribute to the final assembled items' high quality overall. In order to create precise and secure connections, a variety of fitting methods and equipment are used during production procedures. Bolted joints, press fitting, adhesive bonding, welding, and soldering are a few of these methods. Fitting calls for specialized labor and knowledge to guarantee the proper component assembly and alignment.The effectiveness and caliber of production processes have substantially increased because to advancements in fitting. By enabling precise design and virtual assembly simulations, computer-aided design (CAD) software increases productivity and lowers mistake rates. Accurate alignment and dimensional control are guaranteed during the fitting process with the use of precision measurement tools like coordinate measuring machines and laser alignment systems. Automated assembly lines have sped up and simplified the fitting procedure, lowering human error and boosting output.

REFERENCES

[1] E. Scott, N. Serpetti, J. Steenbeek, and J. J. Heymans, "A Stepwise Fitting Procedure for automated fitting of Ecopath with Ecosim models," *SoftwareX*, 2015, doi: 10.1016/j.softx.2016.02.002.

[2] M. Debevc *et al.*, "Effectiveness of a self-fitting tool for user-driven fitting of hearing aids," *Int. J. Environ. Res. Public Health*, 2021, doi: 10.3390/ijerph182010596.

[3] D. Bates, M. Mächler, B. M. Bolker, and S. C. Walker, "Fitting linear mixed-effects models using lme4," *J. Stat. Softw.*, 2015, doi: 10.18637/jss.v067.i01.

[4] T. Tisenkopfs *et al.*, "Territorial fitting of small farms in Europe," *Glob. Food Sec.*, 2020, doi: 10.1016/j.gfs.2020.100425.

[5] R. A. Nicholls, "Ligand fitting with CCP4," *Acta Crystallogr. Sect. D Struct. Biol.*, 2017, doi: 10.1107/S2059798316020143.

[6] G. H. Major *et al.*, "Practical guide for curve fitting in x-ray photoelectron spectroscopy," *J. Vac. Sci. Technol. A*, 2020, doi: 10.1116/6.0000377.

[7] M. Wojdyr, "Fityk: A general-purpose peak fitting program," *J. Appl. Crystallogr.*, 2010, doi: 10.1107/S0021889810030499.

[8] C. S. Gillespie, "Fitting heavy tailed distributions: The powerlaw package," *J. Stat. Softw.*, 2015, doi: 10.18637/jss.v064.i02.

[9] D. P. Van Mossel, C. Liu, N. Vining, M. Bessmeltsev, and A. Sheffer, "StrokeStrip: Joint parameterization and fitting of stroke clusters," *ACM Trans. Graph.*, 2021, doi: 10.1145/3450626.3459777.

[10] T. J. Chin, Z. Cai, and F. Neumann, "Robust Fitting in Computer Vision: Easy or Hard?," *Int. J. Comput. Vis.*, 2020, doi: 10.1007/s11263-019-01207-y.

[11] R. T. Kidmose, J. Juhl, P. Nissen, T. Boesen, J. L. Karlsen, and B. P. Pedersen, "Namdinator - Automatic molecular dynamics flexible fitting of structural models into cryo-EM and crystallography experimental maps," *IUCrJ*, 2019, doi: 10.1107/S2052252519007619.

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ANALYSIS OF FORGING PROCESS

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ABSTRACT

Metal is shaped and formed using compressive forces in the extensively used metalworking process known as forging. It is an essential method for creating robust, long-lasting components used in a variety of industries. A summary of the forging process is given in this abstract, with special attention paid to how important it is to the manufacturing industry. The metal is first heated to the forging temperature, which makes it more pliable and is necessary for the forging process. A press or hammer is used to apply compressive forces to the heated metal, which causes it to deform and take on the desired shape. This procedure gives the forged component a higher density and better mechanical qualities. When compared to other production techniques like casting or machining, forging has a number of advantages, including increased strength, higher structural integrity, and superior grain flow. It is frequently utilized in sectors including automotive, aerospace, oil and gas, and construction where components with high performance and dependability are necessary.

KEYWORDS: *Alloys, Fire, Forging, Furnace, Heating, Stock.*

INTRODUCTION

The earliest method of shaping utilized to create little items for which size accuracy is not as crucial is forging. The blacksmith shapes the parts by heating them in an open fire or hearth and applying compressive pressures to them with hammers.To put it another way, forging is the process of plastically deforming metals at high temperatures into a specific size or shape by applying compressive forces using hand hammers, tiny power hammers, dies, presses, or upsetting machines. At a temperature of around 980°C, when the metal is completely plastic and can be easily deformed or shaped under pressure, it primarily consists of changing or altering the shape and section of the metal by hammering. The smithy or smith's shop is the location where the various forging processes are completed. Steel, for example, can be bent while still in a cold condition, but adding heat reduces the yield point and facilitates permanent deformation. The forging process can be carried out manually or using a machine hammer. Hot forging and cold forging are two different types of forging techniques, and each has its own unique traits, benefits, and drawbacks[1]–[3].

Blacksmith labour, also known as the hand forging method, is frequently used to produce small items utilising heated workpieces and hammers. Even though certain machinery, such as power hammers, can occasionally be employed, it is still a manually managed process.Therefore, black-smithy is a procedure in which metal can be melted and sculpted to its specifications using blacksmith tools and either a hand hammer or power hammer. Small parts are heated in an open fire or hearth and formed with hand tools while being controlled by the smithy worker. A smithy shop is where this work is done. Open face dies are used in smith forging or hand forging, where the heated metal is hammered on by hand to get the required shape using judgement.Machine forging uses forging dies and is typically used to produce exact items in large quantities. Closed impression dies are used in drop forging, and the metal flows dramatically through the dies as a result of repeated blows or impacts, forcing the plastic metal to take on the shape of the dies. A variety of procedures are taken to produce the final shape of the product from basic materials. The following list includes some of the benefits, drawbacks, and applications of forging operations.

Advantages of Forging

The following list of forging benefits includes some popular ones.

1. The high ductility and excellent resistance to impact and fatigue stresses of forged parts.
2. Forging improves the metal's atomic structure.
3. Compared to producing a similar item by cutting from a solid stock and then shaping it, it results in significant time, labor, and material savings.
4. The unidirectional fiber previously produced by rolling is distorted during forging, which also boosts strength by determining the orientation of the grains.
5. Due to the intense working, defects are rarely discovered, making them highly reliable.
6. The forging operation can produce a good degree of accuracy.
7. Welding the forged components is simple.

Disadvantages of Forging

The following list of forging disadvantages is provided.

1. Rapid oxidation of the metal surface during forging at a high temperature causes scaling, which erodes the dies.
2. It is challenging to maintain the tight tolerances used in forging processes.
3. Forging imposes restrictions on pieces with undercuts, complex forms, and other features.
4. Forging cannot be used to easily work with some materials.
5. Forging dies have substantial startup costs and ongoing costs for maintenance.
6. If metals are treated below a certain temperature limit, they crack or deform.
7. Forging die maintenance is also highly expensive.

Application of Forging

It is possible to forge almost any metal or alloy. High-carbon and alloy steels take more skill and effort to forge than low- and medium-carbon steels, which may be hot forged easily. Carbon alloy steels, wrought iron, copper-base alloys, aluminum alloys, and magnesium alloys are the most common materials for forging. For aerospace applications, titanium, nickel-based super-alloys, and stainless steels are specifically forged.

Crank shafts made of alloy steel are a good example of a forged product.One of the most significant manufacturing processes is forging, which is widely used in the production of tiny tools, rail-road equipment, cars, trucks, and aviation parts. Additionally, these procedures are widely employed in the production of tractor parts, shipbuilding, the bicycle industry, railway components, agricultural gear, etc**.**

Forgeability

The ease with which forging is done is called forgeability. The forgeability of a material can also be defined as the capacity of a material to undergo deformation under compression without rupture. Forgeability increases with temperature up to a point at which a second phase, e.g., from ferrite to austenite in steel, appears or if grain growth becomes excessive. The basic lattice structure of metals and their alloys seems to be a good index to their relative forgeability. Certain mechanical properties are also influenced by forgeability. Metals which have low ductility have reduced forgeability at higher strain rate whereas highly ductile metals are not so strongly affected by increasing strain rates. The pure metals have good malleability and thus good forging properties. The metals having high ductility at cold working temperature possesses good forgeability. Cast parts, made up of cast iron are brittle, and weak in tension, though they are strong in compression. Such parts made using cast iron tend to need to be bulky and are used where they will not be subjected to high stresses. Typical examples are machine bases, cylinder blocks, gear-box housings etc. Besides the above factors, cost is another major consideration in deciding whether to cast a component or to forge it. An I.C. engine connecting rod is a very good example of where a forging will save machining time and material, whereas the cylinder block of the same engine would be very expensive if produced by any process other than casting[4]–[6].

Another good point associated with casting is that big or small complex shapes can easily be cast. Small parts can directly be machined out from regular section materials economically. A part machined out from the rolled steel stock definitely possesses better mechanical properties than a conventionally cast part. Sometimes the shape and size of a part would mean removing a large amount of material by machining, it is sometimes more economical to forge the part, thereby reducing the machining time and the amount of material required. The main alloys for cold forging or hot forging are most aluminium and copper alloys, including the relatively pure metals.

Carbon steels with 0.25 % carbon or less are readily hot forged or cold-headed. High carbon and high alloy steels are almost always hot forged. Magnesium possessing hexagonal close packed (HCP) structure has little ductility at room temperature but is readily hot forged. Aluminium alloys are forged between 385°C and 455°C or about 400°C below the temperature of solidification. Aluminium alloys do not form scale during hot forging operations, die life is thus excellent. Copper and brasses with 30% or less zinc have excellent forgeability in cold working operations. High zinc brasses can be cold forged to a limited extent but are excellent hot forging alloys. Magnesium alloys are forged on presses at temperature above 400°C. At higher temperatures, magnesium must be protected from oxidation or ignition by an inert atmosphere of sulphur dioxide.

DISCUSSION

Forgeable Materials

Two-phase and multi-phase materials are deformable if they meet certain minimum requirements. The requirement of wrought metals is satisfied by all pure metals with sufficient number of slip planes and also by most of the solid solution alloys of the same metal. Wrought alloys must possess a minimum ductility that the desired shape should possess. To be a forgeable metal, it should possess the required ductility. Ductility refers to the capacity of a material to undergo deformation under tension without rupture. Forging jobs call for materials that should possess a property described as ductility that is, the ability to sustain substantial high plastic deformation without fracture even in the presence of tensile stresses. If failure occurs during forging, it is due to the mechanism of ductile fracture and is induced by tensile stresses. A material of a given ductility may fail very differently in various processes, depending on the deforming conditions imposed on it. Forgeable metals are purchased as hot-rolled bars or billets with round or rectangular cross the sections. Forgeable materials should possess the required ductility and proper strength. Some forgeable metals are given as under in order of increasing forging difficulty.

1. Aluminum alloys
2. Magnesium alloys
3. Copper alloys.
4. Carbon and low alloy steels
5. Martensitic stainless steels
6. Austenitic stainless steels
7. Nickel alloys
8. Titanium alloys
9. Columbium alloys
10. Tantalum alloys
11. Molybdenum alloys
12. Tungsten alloys
13. Beryllium

Heating Devices

Forgeable metals are heated either in a hearth or in a furnace. The hearths are widely used for heating the metals for carrying out hand forging operations. Furnaces are also commonly used for heating metals for heavy forging. The forging job is always heated to the correct forging temperature in a hearth or in a furnace located near the forging arrangements. Gas, oil or electric-resistance furnaces or induction heating classified as open or closed hearths can be used. Gas and oil are economical, easily controlled and mostly used as fuels. The formation of scale, due to the heating process especially on steel creates problems in forging. A non-oxidizing atmosphere should, therefore, be maintained for surface protection. Special gas-fired furnaces have been developed to reduce scaling to minimum. Electric heating is the most modern answer to tackle scaling and it heats the stock more uniformly also. In some cases, coal and anthracite, charcoal containing no sulphur and practically no ash are the chief solid fuels used in forging furnaces. Forge furnaces are built raise temperatures up to 1350°C in their working chambers.Figure 1 shows a typical hearth. They should be sufficiently large to allow proper combustion of the fuel, and to obtain uniform heating of the forging jobs. Each heating furnace consists of parts including firebox, working chamber, chimney, flues, re-cuperator or regenerator, and various auxiliary arrangements[7]–[9].

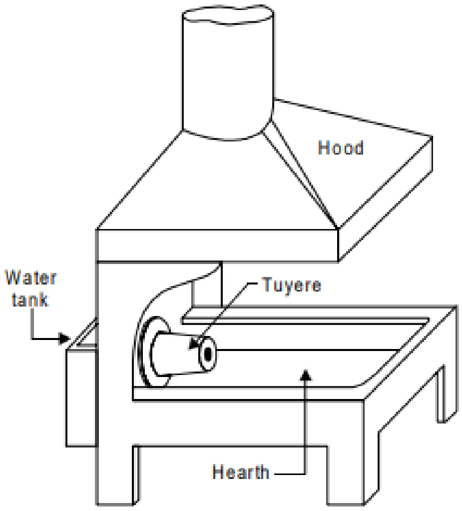

Figure 1: Shows a typical hearth (wordpress.com).

Box or Batch Type Furnaces

These furnaces are the least expensive furnaces widely used in forging shops for heating small and medium size stock. There is a great variety of design of box-type furnaces, each differing in their location of their charging doors, firing devices and method, employed for .charging their products. These furnaces are usually constructed of a rectangular steel frame, lined with insulating and refractory bricks. One or more burners for gas or oil can be provided on the sides. The job-pieces are placed side by side in the furnace using a slot through a suitable tong. It is therefore sometimes called slot type furnace.

Rotary Hearth Furnaces

These are set to rotate slowly so that the stock is red to the correct temperature during one rotation. These can be operated by gas or oil fuels.

Continuous or Conveyor Furnaces

These furnaces are of several types and are preferred for larger stock. They have an air or oil-operated cylinder to push stock end-to-end through a narrow furnace. The pieces are charged at one end, conveyed through the furnace and moved at other end at the correct temperature for the forging work.

Induction Furnaces

These furnaces are very popular because induction greatly decreases scale formation and can often be operated by one person. The furnace requires less maintenance than oil or gas-fired furnaces. In induction furnaces the stocks are passed through induction coils in the furnaces. Delivery to forging machine operator can be effected by slides or automatic handling equipment.

Resistance Furnaces

These furnaces may be easily automated and operate more quickly than induction furnaces. The circuit of a step-down transformer is linked to the stock in a resistance heating boiler. Along with the furnace, fixtures are provided for retaining various length, shape, and diameter of stock. Nevertheless, the fixtures are frequently relatively straightforward and can be altered to accommodate a family of elements.

Open fire and stock fire furnace

The fire must be kept clean and clear of extra clinkers or dust because it is crucial to the effective heating of stock. Uneven heating will ensue if work is placed on top of a fire since it will get hot underneath and stay chilly on top because it is exposed to the air. The same is true for something that is red down in the fire but at the same time up against the tyre; it will heat up on one side while receiving a blast of cold air from the tyre on the other. The hearth of the fire is the ideal location for heating the task. The two most popular firing techniques in forging are open fire and stock fire, which are explained below.

Open fire

Figure 2 depicts an open fire. The coke from the previous fire is used to build this sort of fire, which is extremely useful for general heating operations and is covered with green petroleum, in the empty space in front of the tyre nozzle. As the fire goes out, coke from the top and sides is dragged towards the core, and additional green coal is added either from the supply kept on the forge's front place or from the outside.Figure 2 illustrates an open fireThe tasks or workpieces must be covered with a layer of coal, which must then be softly dampened with water and hammered down with a flat shovel to produce a flame at a single point. The coal should be poked free in the proper location for the flame. It needs to be rotated sometimes to provide even heating of the work on all sides.

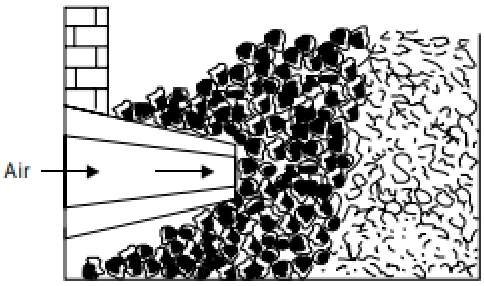

Figure 2: Illustrates an open fire.(wordpress.com).

Stock Fire

Figure 3 shows a stock fire that is meant to burn for a number of hours. This kind of fire is frequently helpful when working with large parts and needs to maintain heat for a while. To achieve uniform heating of the project, it is necessary to rotate the job or work in all directions. Such a fire is constructed around a block of the necessary size that is positioned close to the turbine nozzle and upon which coal dampened with water that is tightly built into the shape of a mound or "stock" is placed. For use in stock fires, fine coal or pulverized coal is appropriate. In order to avoid the stock from being broken, the block is then pulled away from the hearth's bed with a rotating force, creating a tunnel with an aperture at the top. Then, a fire is started in the opening. A tiny amount of coal is taken from the tunnel's bottom, and a cavity is created there so that clinker can fall there. The work is heated here, and as the fire dies down, it is occasionally carefully coated with brand-new coke fuel.

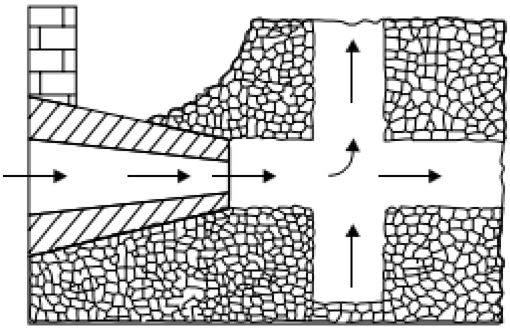

Figure 3: illustrates a stock fire.(wordpress.com).

Fuels used in Forging Shop

The three types of fuels that are utilized in forging shops are solid, liquid, and gaseous, and they are each explained below.

Solid Fuels

Peat, charcoal, coke, wood, coal, anthracite, peat, pulverized fuel, etc.

Liquid Fuels

Petroleum, kerosene, tar oil, and crude oil.

Gaseous Fuels

Heat is produced using natural gas as well as some artificially produced gases.

The following fundamental qualities, which are listed below, should always be present in good gasoline.

1. The fuel must be able to produce the necessary heat.
2. It ought to have finished burning.
3. It ought to be really effective.
4. It shouldn't emit too much smoke or ash into the air.
5. It should be affordable, simple to use, and readily available.

Control of heating devices

The following points should always be taken into account for effective regulation of heating devices like a fireplace or forging furnace.

1. A stream of air is sent into the burning coke through the tuyre, which is the nozzle pointing into the hearth. A centrifugal blower is used to supply the air.
2. The tuyre is equipped with a water jacket to protect it from burning away because the hotter section of the fire is near to the tuyre aperture.
3. The hood placed above the fireplace collects smoke, fumes and other pollutants and exhausts them outside the building through the chimney.

4. Coke or blacksmithing coal can be used as the fire's fuel. Use a gas poker if possible, or else paper and sticks to start the fire.
5. As the fire cools, clinker will form from impurities, which must be cleaned from the fire's bottom.
6. By applying forced draught, the blowers are employed to regulate the air supply. Regulators regulate the fire's temperature and draught.
7. Blowers provide an appropriate flow of air at the proper pressure, which is crucial for the fuel to burn properly.
8. An effective way to provide air in a forging hearth is with a centrifugal blower powered by an electric motor.
9. Fire tools like rakes, pokers, and slices are frequently used to manage or control fires, and they are stored close to the side of the hearth. Rakes are used to remove hot work from the fire. A steel rod called a poker is used to poke (stir) the fire in the hearth.
10. To minimize heat loss and air oxidation, position the metal to be heated directly above the compact center of a sufficiently sized fire with extra fuel on top [10].

CONCLUSION

Producing high-strength and long-lasting components requires the important metalworking process of forging. It has benefits like enhanced grain structure, higher strength, and superior mechanical characteristics. The forging industry continues to innovate despite difficulties in producing complex forms and guaranteeing operator safety. With continual advancements, forging continues to be an essential process for fulfilling the demands of contemporary manufacturing industries and producing components that are dependable and work well.

REFERENCES

[1] N. P. Papenberg, S. Gneiger, I. Weißensteiner, P. J. Uggowitzer, and S. Pogatscher, “Mg-alloys for forging applications-A review,” *Materials (Basel).*, 2020, doi: 10.3390/ma13040985.

[2] R. Dindorf and P. Wos, “Energy-saving hot open die forging process of heavy steel forgings on an industrial hydraulic forging press,” *Energies*, 2020, doi: 10.3390/en13071620.

[3] V. R. Duarte, T. A. Rodrigues, N. Schell, R. M. Miranda, J. P. Oliveira, and T. G. Santos, “Hot forging wire and arc additive manufacturing (HF-WAAM),” *Addit. Manuf.*, 2020, doi: 10.1016/j.addma.2020.101193.

[4] D. Suárez Fernández, B. P. Wynne, P. Crawforth, K. Fox, and M. Jackson, “The effect of forging texture and machining parameters on the fatigue performance of titanium alloy disc components,” *Int. J. Fatigue*, 2021, doi: 10.1016/j.ijfatigue.2020.105949.

[5] J. O. Obiko, F. M. Mwema, and H. Shangwira, “Forging optimisation process using numerical simulation and Taguchi method,” *SN Appl. Sci.*, 2020, doi: 10.1007/s42452-020-2547-0.

[6] R. Kuziak and A. Barełkowski, “Development of a technology of isothermal annealing with the use of the forging heat for chromium-molybdenum steel,” *Mater. Des.*, 2021, doi: 10.1016/j.matdes.2021.109590.

[7] J. O. Obiko, F. M. Mwema, and M. O. Bodunrin, “Finite element simulation of X20CrMoV121 steel billet forging process using the Deform 3D software,” *SN Appl. Sci.*, 2019, doi: 10.1007/s42452-019-1087-y.

[8] A. C. de F. Silveira, W. L. Bevilaqua, V. W. Dias, P. J. de Castro, J. Epp, and A. da S. Rocha, “Influence of hot forging parameters on a low carbon continuous cooling bainitic steel microstructure,” *Metals (Basel).*, 2020, doi: 10.3390/met10050601.

[9] N. Karunathilaka *et al.*, “Effect of lubrication and forging load on surface roughness, residual stress, and deformation of cold forging tools,” *Metals (Basel).*, 2019, doi: 10.3390/met9070783.

[10] K. I. Sugimoto, T. Hojo, and A. K. Srivastava, “Low and medium carbon advanced high-strength forging steels for automotive applications,” *Metals (Basel).*, 2019, doi: 10.3390/met9121263.

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EXPLICATION OF FOUNDRY TOOLS AND EQUIPMENT

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ABSTRACT

The creation of high-quality metal castings is facilitated by the use of foundry tools and equipment, which are crucial components of the casting process. The significance of foundry tools and equipment is highlighted in this abstract, along with their role in various casting process stages, from pattern preparation through post-casting operations. It goes over various tools and equipment used in foundries and highlights how crucial they are to guaranteeing productivity, precision, and safety. The term "foundry tools and equipment" refers to a broad category of devices and pieces of machinery used in various casting-related operations. To ensure that patterns precisely depict the desired casting shape and features, patterns are shaped and refined using pattern preparation equipment including saws, chisels, and planes. In order to properly compact the sand and create gating systems, molding tools like rammers, shovels, and sprue cutters are used when making molds.

KEYWORDS: *Boxes, Metal, Molding, Molten, Sand, Tools.*

INTRODUCTION

Many various tools and pieces of equipment are utilized in the foundry shop to perform tasks like sand preparation, molding, melting, pouring, and casting. They can be roughly divided into hand tools, flasks, power-operated equipment, metal melting equipment, and fettling and finishing equipment's. In the process of creating molds, molders employ a variety of hand tools. Tools for sand conditioning are mostly used to prepare the various kinds of core sand and molding sand. Flasks are frequently used to make sand molds, store molten metal, and transport the latter from one location to another. In foundries, processes are mechanized using power-operated equipment. They comprise a number of different kinds of molding machines, power puzzles, sand mixers and conveyors, grinders, etc. Various types of melting furnaces, such as cupola, pit, and crucible furnaces, are included in the metal melting equipment. Equipment for fettling and finishing is also utilized in foundry work to clean and complete the casting. The following are some general tools and equipment used in foundries[1]–[3].

Hand tools used in foundry shop

There are quite a few popular hand tools used in foundry shops. The following foundry tools that are regularly used by molders are described in brief below.

Hand riddle

Figure 1 depicts a hand riddle. It is made up of a screen with a typical circular wire mesh and a circular hardwood frame. It is typically used to clean the sand and remove foreign objects like nails, shot metal, wood splinters, etc. For riddling enormous amounts of sand, power-operated riddles are also available.

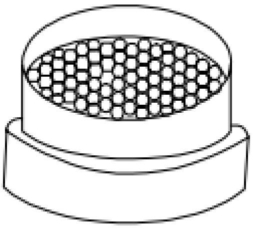

Figure 1: Shows hand riddle (wordpress.com).

Shovel

As seen in Figure2 a shovel. It is made out of a steel pan with a lengthy wooden handle. By hand, it is used for foundry sand conditioning, tempering, and mixing. The molding sand is also transferred and transformed using it to the container, molding box, or flask. It must always be maintained spotless.

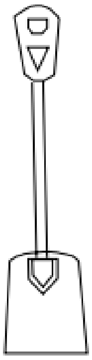

Figure 2: Shows a shovel (wordpress.com).

Rammers

In Figure 3, rammers are depicted. These are necessary for packing or compacting the molding sand mass in the molding box uniformly all around the design. The four most popular types of rammers used in ramming are the hand rammer, peen rammer, floor rammer, and pneumatic rammer.

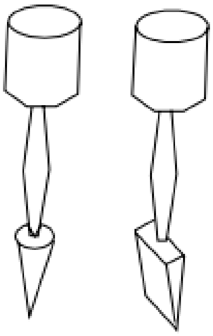

Figure 3: Shows a rammer (wordpress.com).

a. Hand rammer

Typically, it is made of metal or wood. It has a solid cylindrical shape at one end known as the butt, and a wedge-shaped construction at the other end known as the peen. Sand is rammed with it during bench molding work.

b. Peen rammer

It has a metallic rod that is fashioned into a wedge shape at the bottom. It is typically used to fill pockets and comers with molding sand.

c. Floor rammer

It is made out of a long steel bar with a flat section on one end and a peened end on the other. Compared to a hand rammer, it is larger and heavier. Its specific application is in floor molding, where it is used to force sand into larger molds. The molder can use it while standing up due to its length.

d. Pneumatic rammer

They are used to create big molds and save a lot of time and labor.

DISCUSSION

Sprue pin

Figure 4 depicts the sprue pin. A tapered rod made of wood or iron is inserted into the mold cavity to unite it while the cope is being rammed with molding sand. The molten metal is then pumped into the mold using a gating system after its withdrawal from the cope creates a vertical hole in the molding sand known as a sprue[4]–[6].Making a channel through the gating system to pour molten metal into the mould is beneficial.

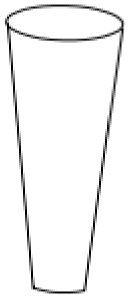

Figure 4: Shows a sprue pin(wordpress.com).

Strike off bar

Strike off bar is a flat bar with a straight edge that can be made of wood or iron (see Figure 5) After ramming, it is used to strike off or remove extra sand from the top of a molding box to make the surface smooth and flat. It has a beveled edge on one side and a flawlessly smooth and plane end.

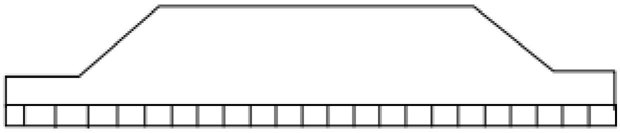

Figure 5: Shows a strike off bar (wordpress.com).

Mallet bar

Similar to a wooden hammer, a mallet is typically found in sheet metal or carpentry shops. The draw spike is driven into the pattern in the moulding shop and then rapped to separate it from the mould surfaces so that the pattern can be removed from the mould cavity easily without damaging the mould surfaces.

Draw spikes

Figure 6 depicts a vent rod. It consists of a thin, spiked steel rod or wire with a bent loop or a wooden grip on one end and a pointy edge on the other. It is used to pierce a series of tiny holes in the molding sand in the coping area after ramming and striking off the excess sand. When pouring molten metal into a mold and allowing it to solidify, a series of tiny holes known as vents holes allow steam and gases to escape or escape in order to obtain sound castings.

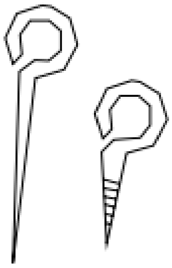

Figure 6: Shows a draw spike (wordpress.com).

Vent rod

Figure 7 depicts a vent rod. It consists of a thin, spiked steel rod or wire with a bent loop or a wooden grip on one end and a pointy edge on the other. It is used to pierce a series of tiny holes in the moulding sand in the coping area after ramming and striking off the excess sand. When pouring molten metal into a mould and allowing it to solidify, a series of tiny holes known as vents holes allow steam and gases to escape or escape in order to obtain a sound casting.

Figure 7: Shows a vent rod (wordpress.com).

Lifters

The lifters in Figure 8 are displayed. They are made of thin steel sections of varying lengths and widths with one end bent at a right angle, and they are also known as cleaners or finishing tools. After the pattern has been removed, they are used to clean, fix, and finish the bottom and sides of deep and narrow gaps in mould cavities. Additionally, they are utilised to remove loose sand from mould cavities.

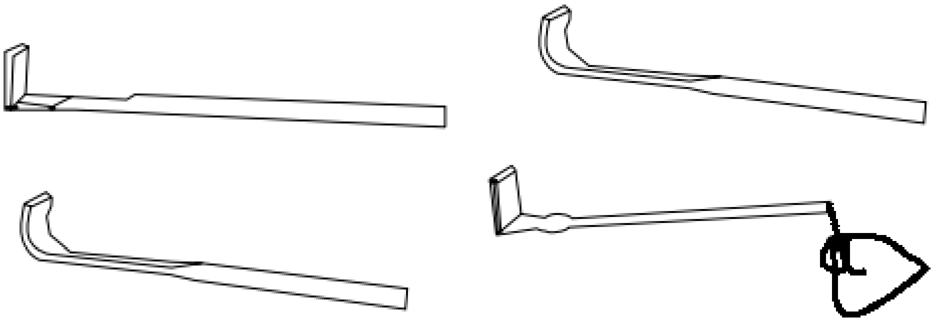

Figure 8: Shows lifters (wordpress.com).

Trowels

They are used to finish the mold's flat surfaces, joints, and parting lines. They are composed of an iron metal blade and a wooden handle. Common trowel metal blade designs include pointed, curved, and rectangular blades. The main purpose of the trowels is to slick or smooth the surfaces of molds. They can also be used to restore the mold surfaces and cut in-gates.

Slicks

They are also known as little double-ended mold finishing tools, and their typical usage is to fix and smooth off the mold's edges and surfaces after the pattern has been removed. The heart and leaf, square and heart, spoon and bead, and heart and spoon slick varieties are the most often used slicks. The shapes of the slicks play a big role in their nomenclatures.

Smoothers

They are given many names based on its intended usage and shape. They are often referred to as finishing tools and are frequently used for molding's flat, rounded, and squared-off surfaces, as well as its corners and edges.

Swab

It is a little brush made of hemp fiber that is used to moisten the sand mold edges that are in touch with the pattern surface before removing the pattern. The molding sand from the mold surface and pattern is removed using it. Additionally, it is utilized to coat the mold faces of dry sand molds with liquid blacking.

Flasks

The common flasks, which are employed in foundries as mold boxes, crucibles, and ladles, are also known as containers.

Open molding boxes

In Figure 9, open moulding boxes are displayed. They are constructed with a hinge at one corner and a lock at the other. They are often referred to as "snap moulding boxes," and they are typically used to create sand moulds. A snap moulding has a wood construction with a corner hinge. It has specific uses in bench moulding for small nonferrous castings made of green sand. The mould is initially created in the snap flask, after which it is taken out and a steel jacket is put in its place. As a result, multiple moulds can be created using the same set of boxes.

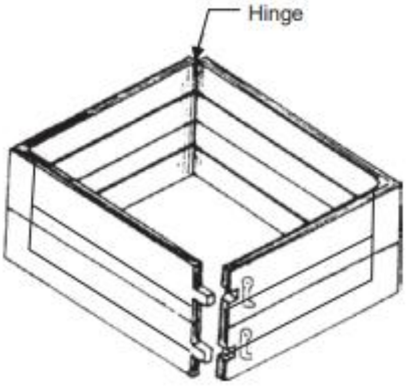

Figure 9: Shows open molding boxes (wordpress.com).

Cast-aluminum tapered closed boxes are becoming more and more popular in contemporary foundries as an alternative to hardwood snap boxes. They have a precisely honed and finished tapering interior surface. This box's solid construction provides greater stiffness and strength than the open kind. After building the moulds, these boxes are likewise taken out.To support gaggers and withstand the weight of the dense quantity of sand, large moulding boxes have ribs and cross bars for reinforcement. The dimensions of the casting determine the size, composition, and structure of the moulding box[7]–[9].

Closed molding boxes

Figure 10 depicts closed molding boxes, which can be two or more components and made of steel, cast iron, or wood.All of the intermediate pieces, if employed, are referred to as cheeks. The bottom section is known as the drag, the top part as the cope.Every component has its own proper mechanism for clamping configurations during pouring.In most cases, green-sand molding uses wooden boxes. Because dry sand molds are heated to dry, metallic boxes are always necessary. Cast iron or steel is used to make large, heavy boxes with handles and grips that can be moved by cranes, hoists, etc. Closed round molding boxes or closed rectangular molding boxes are two different names for closed metallic molding boxes.

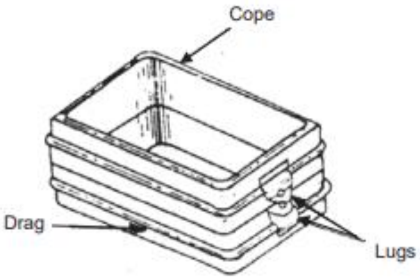

Figure 10: Shows closed rectangular molding box (wordpress.com).

Crucible

Crucibles have a shell constructed of steel or graphite that is lined with an appropriate refractory substance, such as fire clay. Common names for them include metal melting pans. They are filled with the raw material or charge, which is split up into little bits. They are then placed in coke-fired pit furnaces. They are a crucial component of the furnace itself in oil-fired tilting furnaces, and the charge is inserted into them as they are in place. Metals are removed from crucibles after melting and placed in the handle. Instead of moving the molten metal to ladles, they frequently pour it immediately. The molten metal is instead received in a ladle and then poured into the moulds in an oil-fired furnace.

Ladle

It resembles the crucible in shape and has a shell made of steel or graphite that is lined with an appropriate refractory substance, such as fire clay. It is frequently used to take molten metal out of the melting furnace and pour it into the cavity of the mold. Its capacity serves as a measure of its magnitude. A single foundry employee uses small hand shank ladles that have just one handle. It might be offered in a variety of weights up to 20 kg. Large and medium-sized ladles have handles on both sides so that two foundry workers may wield them.

They come in a variety of sizes and can hold between 30 kg and 150 kg. Crane ladles come in extremely large sizes, with capacities ranging from 250 kg to 1000 kg. Even more than a kilogram of molten metal can be held by geared crane ladles. For improved pouring control and to increase worker safety in foundries, ladle handling can be automated. All ladles have an exterior composed of steel or plate that has been properly bent and then welded. There is a refractory lining inside of this casing. The enclosure is designed to have a controlled and precisely directed flow of molten metal at its top. They are frequently employed to transfer molten metal between furnaces and molds.

Power Operated Equipment’s

Power riddles, mechanical conveyors, sand mixers, material handling equipment, sand aerators, and various types of molding machines and sand slingers are among the power powered foundry equipment often used in foundries. Below are some regularly used forms of such equipment.

Molding machines

In order to assist in the preparation of a sand mold, a molding machine functions as a device with a large number of interconnected parts and mechanisms that transmit and direct different forces and motions in the necessary directions. The main tasks of molding machines include pushing molding sand into the mold, rolling the mold upside down or backwards, rapping the pattern, and removing the pattern from the mold. The majority of molding machines combine two or more tasks into one. However, the majority of these devices' primary purpose is to ram sand. When producing numerous, repetitive castings, it is best to use a molding machine because doing so by hand can be tiresome, time-consuming, difficult, and expensive in comparison[10], [11].

CONCLUSION

The manufacture of metal castings is made possible by a variety of tools and equipment, which are crucial to its efficient, accurate, and secure execution. A variety of tools and equipment are used to form patterns, build molds, melt and pour metal, and evaluate casting quality, from pattern preparation to post-casting operations. The efficiency and precision of the casting process are influenced by the selection of the right tools and equipment and by the proper maintenance of that equipment. Instruments that are properly maintained and calibrated guarantee accurate measurements and aid in detecting and resolving any deviations from required standards. The preservation of safe working conditions and attention to safety regulations, such as the appropriate use of protective equipment, are crucial in the foundry setting where safety is of the utmost importance. The effectiveness of operations is increased, and the chance of accidents or injuries is decreased, with adequate instruction on the use of foundry tools and equipment.

REFERENCES

[1] S. Nallusamy, S. R. Seenuvasa, S. Sundar, and G. Majumdar, “Study on enhancement of quality level through a lean approach in an original equipment manufacturer,” *Int. J. Eng. Res. Africa*, 2019, doi: 10.4028/www.scientific.net/JERA.43.145.

[2] V. V. Desnitsky, L. V. Desnitskaya, and I. A. Matveev, “Foundry design scheme,” *Int. J. Mech. Prod. Eng. Res. Dev.*, 2020.

[3] A. Palange and P. Dhatrak, “Lean manufacturing a vital tool to enhance productivity in manufacturing,” 2021. doi: 10.1016/j.matpr.2020.12.193.

[4] K. Pardee *et al.*, “Portable, On-Demand Biomolecular Manufacturing,” *Cell*, 2016, doi: 10.1016/j.cell.2016.09.013.

[5] K. McMillan, K. Flood, and R. Glaeser, “Virtual reality, augmented reality, mixed reality, and the marine conservation movement,” *Aquat. Conserv. Mar. Freshw. Ecosyst.*, 2017, doi: 10.1002/aqc.2820.

[6] Y. I. Gonzales *et al.*, “Analysis of Different Sand Casting Defects in a Medium Scale Foundry Industry-A Review,” *Int. Res. J. Eng. Technol.*, 2020.

[7] I. Wayan Jawat, A. Agung Sagung Dewi Rahadiani, and dan Ni Komang Armaeni, “Produktivitas Truck Concrete Pump Dan Truck Mixer Pada Pekerjaan Pengecoran Beton Ready Mix,” *PADURAKSA*, 2018.

[8] A. V. Batasova, “Metal Casting Equipment in the Bronze Age Burials in Europe,” *Vestn. Sankt-Peterburgskogo Univ. Istor.*, 2021, doi: 10.21638/11701/SPBU02.2021.412.

[9] A. Josan, E. Ardelean, M. Ardelean, and V. Putan, “Management of the activity of quality assurance of cast iron castings in foundries,” 2021. doi: 10.1088/1742-6596/1781/1/012050.

[10] V. Narula and S. Grover, “Application of six sigma DMAIC methodology for reducing defects in a foundry shop,” *Mater. Sci. Forum*, 2015, doi: 10.4028/www.scientific.net/MSF.808.79.

[11] P. R. D. Vaidya, R. Trivedi, T. Rathi, S. Niwal, and S. Panbude, “Implementation Of 5s In Workshop At Dmietr- A Case Study,” *Int. J. Adv. Res. Innov. Ideas Educ.*, 2017.

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OVERVIEW ON HEAT TREATMENT PROCESSES

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ABSTRACT

In the manufacturing sector, heat treatment is a crucial procedure used to improve the qualities of materials. In order to produce high-quality goods, heat treatment procedures that are specifically used in manufacturing processes are discussed, along with how they affect material qualities. Strengthening material strength, maximizing mechanical qualities, strengthening dimensional stability, and raising wear resistance are the main goals of heat treatment in manufacturing. The discussion of various heat treatment techniques, including annealing, quenching, tempering, and surface hardening, emphasizes the methods' particular applicability in industrial processes. In order to achieve the necessary material qualities, the study emphasizes the significance of process variables such temperature control, heating and cooling rates, and holding times. In addition, the importance of precise process control and monitoring procedures is discussed in order to guarantee repeatable and dependable heat treatment results. For production engineers, technicians, and academics working to improve material performance by heat treatment, the data offered in this study is a useful resource.

KEYWORDS: *Austenite, Carbon, Iron, Pearlite, Steel, Temperature.*

INTRODUCTION

Heat treatment is the process of heating and cooling a metal or alloy while it is in the solid form in order to modify its properties. It can also be described as a process of heating and cooling ferrous metals, particularly different types of steels, in which some special qualities are introduced into these metals for accomplishing the special function target, such as softness, hardness, tensile strength, toughness, etc. There are three primary stages to it: heating the metal, soaking it in solution, and chilling the metal. The principle behind heat treatment is founded on the idea that heating and cooling causes a change in the internal structure of metal, giving it the desired qualities. The primary governing factor is the pace of cooling. Rapid cooling of the metal causes hard structure when it is above the critical range. While extremely slow cooling results in mushy structure, the opposite effect. The heating and cooling rates are crucial in any heat treatment process. Cutting, moulding, and other shaping techniques are challenging with hard materials. Because one needs machineable properties in the workpiece while machining in a machine shop, the properties of the job piece may require heat treatment, such as annealing, to produce softness and machineability properties in the workpiece. Furnaces of all shapes and sizes are employed for heating and heat treatment. Such heat treatment furnaces are categorised as follows[1]–[3].

Heat treatment furnaces

Fuel, such as coke, coal, gas (town, blast, or natural), and fuel oil, is used to heat these furnaces. They can be run electrically as well. There are typically two varieties of them. Stationary type (a) There are four different types.

(1) A direct-fired furnace

(2) An indirect-fired furnace

(3) A furnace with many burners

(4) A furnace with recirculation

(b) Movable type

It comes in two varieties.

(1) The kind of automobile bottom

(2) Rotating type

Bath Furnaces

Heating in bath-style furnaces can be accomplished with the use of gas, oil, or electricity. These furnaces can also be divided into:

(1) Types of liquid

(2) Salt baths

(3) Type of lead bath

(4) Oil bath design

Constituents of iron and steel

Cementite is extremely brittle and hard. If the black areas in the image above are examined in more detail, a substance made of alternate layers of light and dark patches may be seen. These layers alternate between cementite and ferrite. 87% ferrite and 13% cementite make up the material known as pearlite. However, the amount of pearlite grows to 0.8% C with an increase in steel's carbon content. At 0.8% C, pearlite makes up the entire steel framework. High carbon steel is, however, referred to as such if the carbon content in steel is further increased as a free element up to 1.5% C.

DISCUSSION

Transformation during heating and cooling of steel

This structural change does not take place at a steady temperature. It takes enough time, and the change needs a variety of temperatures. The transformation range is this area. For instance, the area shown in the iron carbon equilibrium diagram between the hypo and hyper eutectoid steels' lower critical temperature line and higher critical temperature line. The term "critical range" also applies to this area.Figure 1 shows heating and cooling curve of steel.Excessive oxidation or decarburization of the surface may result from overheating over an extended period of time at a high temperature.Figure 2 shows Allotropic changes during cooling of pure iron If the work piece is going to be forged, oxidation could appear as a piece of scale that is pushed into the surface. Large austenite grains occur when steel is heated considerably over the upper critical temperature. In other words, steel lacks ductility and shock resistance and acquires an undesirable coarse grain structure when slowly cooled to room temperature[4]–[6].

Iron-Carbon Equilibrium Diagram

Figure 3 shows, the Fe-C equilibrium diagram in which various structure (obtained during heating and cooling), phases and microscopic constituents of various kinds of steel and cast iron are depicted. The main structures, significance of various lines and critical points are discussed as under.

Structures in Fe-C-diagram

The following are the primary microscopic components of iron and steel:

1. Austenite
2. Ferrite
3. Cementite
4. Pearlite

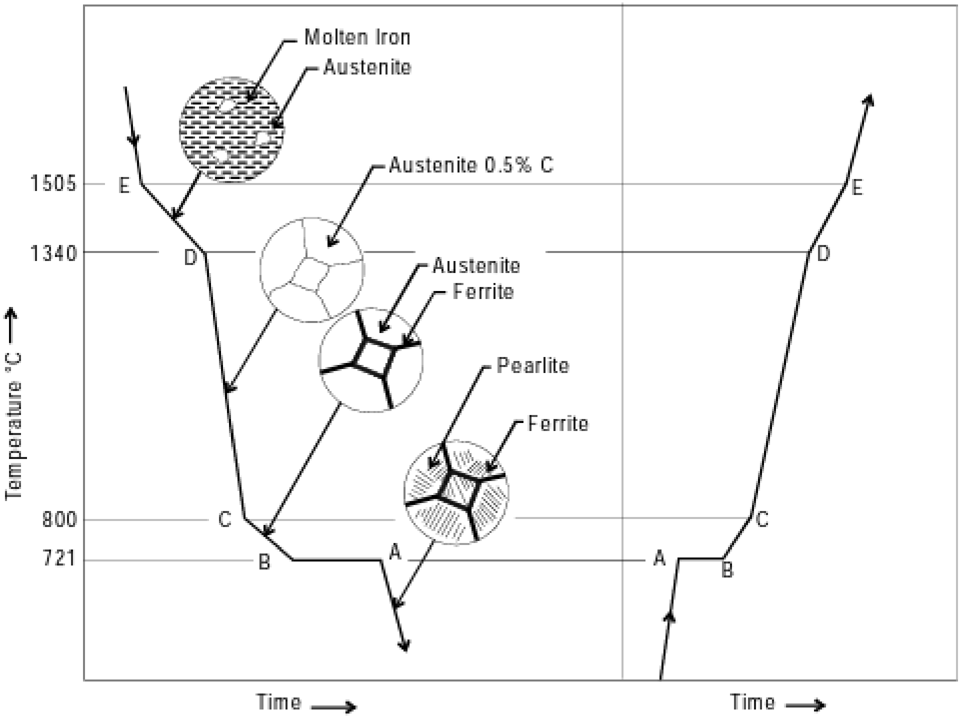

Figure 1: Shows heating and cooling curve of steel (wordpress.com).

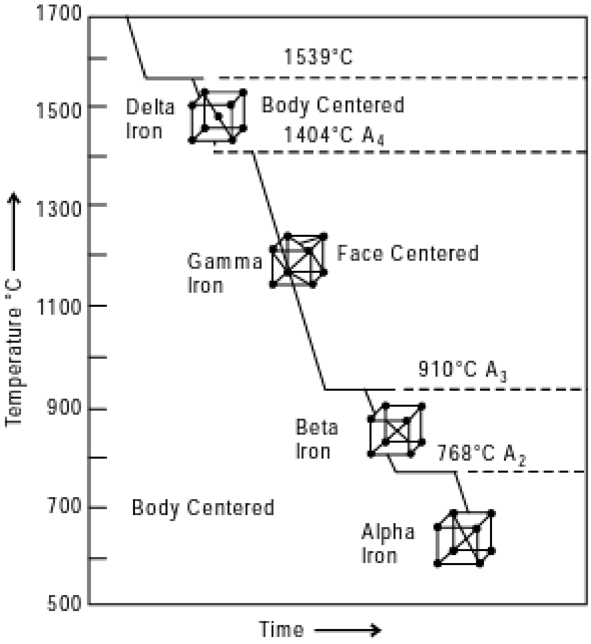

Figure 2: Shows Allotropic changes during cooling of pure iron (wordpress.com).

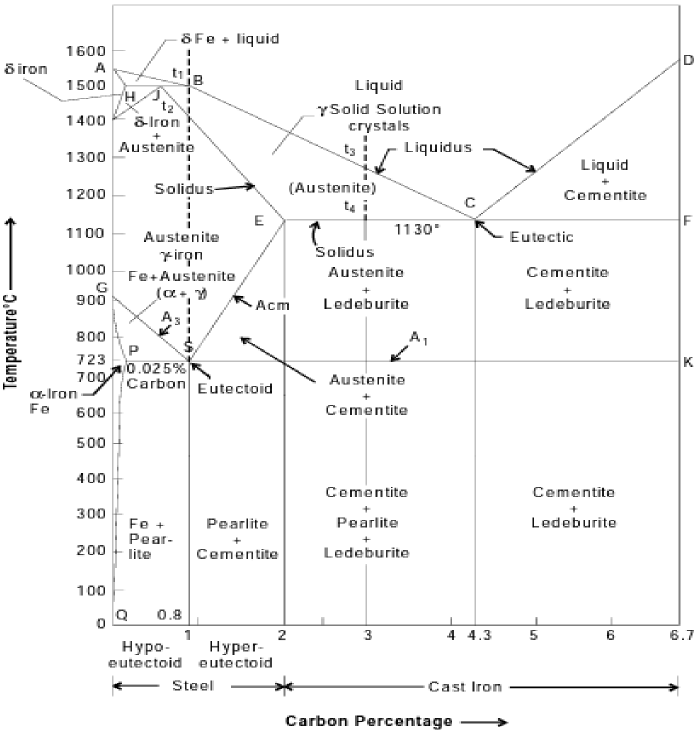

Figure 3: Shows the iron-carbon equilibrium diagram (wordpress.com).

Austenite

Gamma iron contains iron and free carbon (ferrite), which solidifies to form austenite. After reaching a certain temperature while heating the steel, austenite, a hard, ductile, and non-magnetic material, is formed. It has the ability to dissolve a lot of carbon. In the critical or transfer ranges when steel is being heated or cooled. When steel is heated to 1130 °C and contains up to 1.8% carbon, it forms. It begins to change into pearlite and ferrite when the temperature drops below 723 °C. Austenitic steels are non-magnetic and cannot be toughened using conventional heat treatment techniques.

Ferrite

Iron in ferrite contains extremely little to no carbon. It is the name given to soft, ductile pure iron crystals. Ferrite structure is created when low carbon steel is slowly cooled below the critical temperature. Rapid cooling does not cause ferrite to become hard. It is incredibly magnetic and silky.

Cementite

Iron carbide (Fe3C), a chemical combination of carbon and iron, is the substance known as cementite. Cast iron, which contains 6.67% carbon, has a cementite structure in its entirety. All steel with a carbon content of higher than 0.83% contains free cementite. According to the Fe-C Equilibrium diagram, it rises as carbon content rises. It is very challenging. Cast iron's hardness and brittleness are thought to be caused by cementite's presence. Tensile strength is reduced. This is created when carbon and iron combine in specific ways to make iron carbides, which are naturally very hard substances. Cast iron's brittleness and hardness are primarily regulated by cementite content. Below 200°C, it is magnetic[7], [8].

Pearlite

A eutectoid alloy of cementite and ferrite is known as pearlite. It is most common in medium and low carbon steels and takes the mechanical form of an 87:13 ferrite:cementite combination. With an increase in pearlite content in ferrous material, it becomes harder. While ferrite is weak, soft, and ductile, pearlite is relatively strong, hard, and ductile. It is composed of plates that are alternately light and dark. These layers alternate between cementite and ferrite. Pearlite is a mineral whose surface seems like a pearl when viewed under a microscope. Pearlite and cementite are combined to form hard steels, while ferrite and pearlite are combined to form soft steels. The temperature at which ferrite is first rejected from austenite drops as carbon content rises above 0.2% until, at or above 0.8% carbon, no free ferrite is rejected from the austenite. The composition of this steel, known as eutectoid steel, is pearlite. The following phases, which represent the lines, will reveal information about the structure of iron and how it charges as iron with varying percentages of carbon (up to 6%) is heated and cooled**.**

Significance of transformation lines

Line ABCD

The line ABCD indicates that the iron has finished melting above this line during heating. Purely in liquidus form, the metal is in the molten state. The metal is partially solid and partially liquid below and above line AHJECF. Austenite is the name of the metal in solid form. As a result, the line ABCD depicts the temperature at which melting is thought to be complete. Beyond this line, all of the metal is molten. The melting temperature does not follow a straight line; it varies with the amount of carbon present.

Line AHJECF

According to this line, metal begins to melt at this temperature. Since this line is not horizontal, the melting temperatures will vary depending on the amount of carbon present. The metal is solid below this line and has an austenite structure above line GSEC.

Line PSK

The transformation of steels begins at this line, which is horizontal and is found close to 723°C. This line is known as the lower critical temperature line. Steel with varying carbon percentages will change at the same temperature since carbon percentage has no effect on it. The transformation range is the region above the line and up to GSE. This line informs us that during heating, steel with a carbon content of 0.8% or less will begin to change from ferrite and pearlite to austenite.

Line ECF

A line at 1130 °C indicates that cast iron with a C content ranging from 2% to 4.3% should be used. Cast iron will have austenite + ledeburite and cementite + ledeburite below and above this line, respectively.

Critical temperatures

The following temperatures are considered crucial temperatures because they cause structural changes:

1. The upper critical temperature is the temperature along the GSE. (Upper Critical Temperature) is the temperature along the GS during heating where austenite + alpha iron transforms into austenite and vice versa.
2. The temperature along GS where austenite transforms into austenite + alpha iron during chilling as A3 and vice versa during heating.
3. The temperature along line SE when A_{cm} transforms from austenite + cementite to austenite and vice versa.
4. When pearlite heats up and turns into austenite as indicated by A1, the temperature along PSK is known as the lower critical temperature.

Objectives of heat treatment

Due to the structural changes they generate, the following temperatures are regarded as critical temperatures:

1. The temperature along the GSE is the upper critical temperature. The temperature along the GS when austenite + alpha iron changes into austenite and vice versa is known as the (Upper Critical Temperature).
2. The temperature along GS at which, during cooling as A3 and heating as A4, austenite changes into austenite + alpha iron.
3. The temperature along line SE at which austenite and cementite in Acm change into austenite, and vice versa.
4. The temperature along PSK is referred to as the lower critical temperature when pearlite heats up and transforms into austenite, as shown by A1.

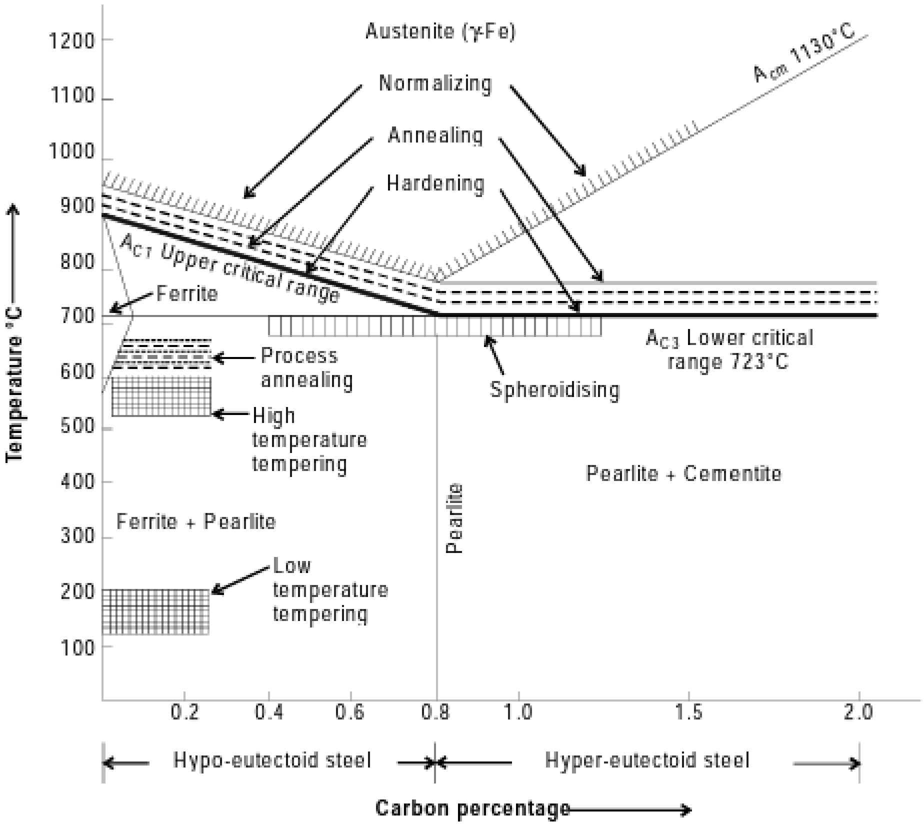

Figure 4: Illustrates heating temperature ranges for various heat treatment process (wordpress.com).

One or more of the following heat treatment procedures may help to achieve the aforementioned heat treatment goals:

1. Normalizing
2. Annealing.
3. Hardening.
4. Tempering
5. Case hardening
   (a) Carburizing
   (b) Cyaniding
   (c) Nitriding
6. Surface hardening
   (a) Induction hardening,
   (b) Flame hardening.

Normalizing

Normalizing is a softening procedure that involves heating iron base alloys 40 to 50 °C beyond the upper-critical limit for both hypo and hyper eutectoid steels, holding that temperature for a predetermined amount of time, and then allowing them to cool in still air till room temperature.The normalizing temperature ranges for both hypo- and hyper-carbon steel are shown in Figure 4.

Objectives

1. For metal softer
2. Improve grain size
3. Increase machinability after forging and rolling
4. Refine grain structure
5. Enhance weld structure
6. Get steel ready for sub-heating

Annealing

It is a procedure for softening iron base alloys in which the temperature is raised above the transformation range, maintained there for the appropriate amount of time, and then slowly cooled (at a rate of 30 to 150°C per hour) below the transformation range inside the furnace. In the case of hypo eutectoid steel, heating is done 20°C above the higher critical temperature point, and the same amount above the lower critical temperature point in the case of type eutectoid steel. The temperature ranges for the annealing or softening process of both hypo- and hyper-carbon steel are shown in Fig. 4. When steel is slowly cooled, its structure transforms into pearlite and cementite for hyper eutectoid steel, pearlite and ferrite for eutectoid steel, and ferrite and pearlite for hypo eutectoid steel. It takes half an hour to an hour to hold the material in the furnace. Austenite structure will be reached at this temperature as ferrous metals are heated above the transition range. To have acceptable annealing qualities for free machining, a specified cooling rate is needed for a particular type of structure. Carbon steels are cooled down at a specific rate, typically 150-200°C per hour, while alloy steel, in which austenite is very stable and should be cooled much lower (30°C to 100°C per hour), after being heated and held in and with the furnace and buried in non-conducting media such as sand, lime, or ashes. In order to generate pearlite and cementite structures in hypo-eutectoid steel, a pearlite structure in eutectoid steel, and a pearlite and cementite structure in hyper-eutectoid steel, austenite must dissolve at two degrees of supercooling during annealing. Ferrite grains are big and regular in effectively annealed steel, whereas cementite and ferrite make up pearlite. In order to achieve a coarse grain structure for free machining, hypo-eutectoid hot wrought steel may undergo complete annealing. Steel becomes much harder (Brinell hard) and slightly less ductile when it is cold wrought. Then, by means of what is known as recrystallization or process annealing, the ductility of steel may be recovered**.**

Objectives of Annealing

The following goals are accomplished with annealing:

1. Make the steel softer.

2. Reduce internal tension
3. Reduce or do away with structural heterogeneity.
4. Improve grain sizing.
5. Make machining easier.
6. Boost ductility and toughness or restore them.

Annealing is of two types

i. Process annealing
ii. Full annealing

Spheroidization

It is the lowest temperature range in the annealing process, when iron base alloys are heated 20 to 40°C below the lower critical temperature and kept for a significant amount of time, for example, four hours is advised for a piece with a diameter of 2.5 cm. It is then allowed to cool inside the furnace itself very gradually at ambient temperature. The heating temperature ranges for the carbon steel spheroid zing process are shown in Fig. 4. Steel gains softness as a result of this process, in which the cementite, which is the combined form of carbon, transforms into globular or spheroidal particles and leaves ferrite in the matrix. Because machining becomes challenging after normalizing steels, which increases their hardness to 229 BHN, these steels are first spheroid zed before being machined. Steels with 0.6 to 1.4% carbon content are subjected to this procedure. The spheroid zing goals are listed below[9], [10].

1. To reduce tensile strength.
2. To improve ductility;
3. To facilitate machining;
4. To provide structure for a future hardening procedure.

CONCLUSION

The manufacture of high-quality materials with improved qualities is made possible by the crucial role that heat treatment plays in manufacturing processes. Manufacturers can raise material strength, optimize mechanical qualities, improve dimensional stability, and boost wear resistance by using particular heat treatment processes to satisfy the demands of various applications. The material composition, required qualities, and the manufacturing process itself all influence the choice of heat treatment method. In order to make material more suited for forming and machining operations, annealing is used to reduce stress, increase ductility, and clean up the grain structure. While tempering strikes a balance between toughness and hardness, making it appropriate for components subjected to dynamic loads, quenching offers high hardness and increased wear resistance. Case hardening and induction hardening are two surface hardening processes that are used to increase wear resistance and prolong the life of vital components.

REFERENCES

[1] X. M. Hou, Y. J. Yang, and J. Qian, “Phase transformation behaviors and mechanical properties of NiTi endodontic files aftegold heat treatment and blue heat treatment,” *J.*

Oral Sci., 2021, doi: 10.2334/josnusd.19-0331.

[2] S. Ghouse, R. N. Oosterbeek, A. T. Mehmood, F. Vecchiato, D. Dye, and J. R. T. Jeffers, “Vacuum heat treatments of titanium porous structures,” *Addit. Manuf.*, 2021, doi: 10.1016/j.addma.2021.102262.

[3] J. Fiocchi, A. Tuissi, and C. A. Biffi, “Heat treatment of aluminium alloys produced by laser powder bed fusion: A review,” *Materials and Design*. 2021. doi: 10.1016/j.matdes.2021.109651.

[4] Q. Fang, J. Sun, D. Cao, Y. Tuo, S. Jiang, and G. Mu, “Experimental and modelling study of the denaturation of milk protein by heat treatment,” *Korean J. Food Sci. Anim. Resour.*, 2017, doi: 10.5851/kosfa.2017.37.1.44.

[5] A. A. Panou, K. Akrida-Demertzi, P. Demertzis, and K. A. Riganakos, “Effect of Gaseous Ozone and Heat Treatment on Quality and Shelf Life of Fresh Strawberries during Cold Storage,” *Int. J. Fruit Sci.*, 2021, doi: 10.1080/15538362.2020.1866735.

[6] Y. Morimoto *et al.*, “Heat treatment inhibits skeletal muscle atrophy of glucocorticoid-induced myopathy in rats,” *Physiol. Res.*, 2015, doi: 10.33549/physiolres.932942.

[7] Q. Wang, X. Wu, C. Yuan, Z. Lou, and Y. Li, “Effect of saturated steam heat treatment on physical and chemical properties of bamboo,” *Molecules*, 2020, doi: 10.3390/molecules25081999.

[8] B. B. Galizoni, A. A. Couto, and D. A. P. Reis, “Heat treatments effects on nickel-based superalloy inconel 713C,” *Metals (Basel).*, 2019, doi: 10.3390/met9010047.

[9] W. Shangguan, Y. Gong, R. Zhao, and H. Ren, “Effects of heat treatment on the properties of bamboo scrimber,” *J. Wood Sci.*, 2016, doi: 10.1007/s10086-016-1574-3.

[10] P. Jovičević-Klug, M. Jovičević-Klug, T. Sever, D. Feizpour, and B. Podgornik, “Impact of steel type, composition and heat treatment parameters on effectiveness of deep cryogenic treatment,” *J. Mater. Res. Technol.*, 2021, doi: 10.1016/j.jmrt.2021.07.022.

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A STUDY ON HOT WORKING OF METALS

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ABSTRACT

The deformation of metals at high temperatures is a part of the metal forming process known as hot working. The benefits of this procedure include improved material characteristics, increased ductility, and decreased forming forces. In this abstract, we give a general review of hot working, its numerous methods, and how it affects the mechanical characteristics and microstructure of metals. We also talk about the difficulties of hot working and emphasize how crucial process factors are to getting the results we want. We also examine the uses of hot working in many fields and its potential for development in the future. This abstract's overall goal is to give a brief overview of hot working and its importance in the field of metal forming.

KEYWORDS: *Deformation, Hot, Metal, Rolling, Temperature, Working.*

INTRODUCTION

The mechanical working of metals is another name for metal forming. It is frequently desirable to perform metal forming procedures in order to give the metal a new shape or to enhance its qualities.Cutting shaping, such as the machining operations carried out on various machine tools, and non-cutting shaping, such as forging, rolling, pressing, etc., are two categories of shaping in the solid state. Mechanical working techniques are shaping procedures that do not use cutting or machining. It refers to a deliberate, long-lasting plastic deformation of metals beyond of their elastic range. The primary goals of metalworking procedures are to produce the correct shape and size in metals while subjecting them to external forces[1]–[3]. These procedures are used to produce metal with the best possible mechanical qualities, remove any internal holes or cavities, and increase the density of the metal.

Because plastic deformation improves the mechanical properties of metals, it is frequently used to work with metals. A metal can be mechanically deformed or heated and then subjected to a modest amount of force to obtain the desired distortion. As a result, the metal's impurities grow longer with the grains, breaking and dispersing throughout the metal as a result. Additionally, this increases mechanical strength while reducing contaminants' negative effects. When the tension in a metal induced by the applied forces reaches the yield point, plastic deformation of the metal occurs. Deformation by slip and twin formation are the two common mechanisms that control this plastic deformation of a metal. In the first scenario, it is assumed that each metal grain is made up of a number of unit cells that are arranged in a variety of planes, and that the metal slips or deforms along the slip plane that is subjected to the greatest shearing stress as a result of the applied pressures. The latter scenario involves deformation along two parallel axes that pass diagonally through the unit cells.

The area of the grains covered between these parallel planes is referred to as the twinned region, and they are known as twinning planes. When plastic deformation takes place, the metal seems to flow in various directions when it is solid, depending on the processing and the direction of applied forces. In the direction of metal flow, the metal's crystals or grains enlarge. However, after the metal surface has been polished and appropriately etched, this metal flow may be easily seen under a microscope. Fibre flow lines are the visible lines. At room temperature or higher temperatures, the aforementioned deformations can be performed. Because the link between the atoms in the metal grains is weaker at higher temperatures, deformation occurs more quickly. The qualities of a material known as plasticity, ductility, and malleability are those that permanently hold the deformation caused by applied forces; as a result, these metal properties are crucial for metalworking operations.

The ability of a material to experience some level of permanent deformation without rupturing or failing is known as plasticity. Only until the elastic range has been breached can plastic deformation occur. Such a material's property is crucial for many other hot and cold working processes, including forming, shaping, and extrusion. Clay, lead, and other materials are plastic at ambient temperature, while steel is plastic when heated to the forging temperature. Generally speaking, this feature gets better as the temperature rises.

The ability of a material to be pulled into wire when subjected to tensile force is known as ductility. A ductile substance needs to be both durable and plastic. The terms % elongation and percent reduction in area are frequently employed as empirical measures of ductility and are utilised to measure ductility in most cases. In order of decreasing ductility, the ductile materials frequently utilised in engineering practise are mild steel, copper, aluminium, nickel, zinc, tin, and lead.

When a material is malleable, it may be heated or cooled and flattened into thin sheets without shattering. Plastic should be a malleable substance, but strength is not required. In order of decreasing malleability, common engineering materials include lead, soft steel, wrought iron, copper, and aluminium. Metals like steel, aluminium, copper, tin, and copper are known for being very malleable.

Recrystallization

The plastic flow of the metal and changes to the grain forms occur during the plastic deformation process in metal forming. At the site of internal tensions created in the metal by plastic deformation, new grains begin to grow at higher temperatures. The formation of new grains is rapid and continuous at a high enough temperature until the metal is entirely made up of the new grains. Recrystallization, the process of creating new grains, is said to be finished when the metal structure is made up entirely of brand-new grains. The recrystallization temperature of the metal is the temperature at which recrystallization is complete. The distinction between cold working and hot working procedures is made at this point. Cold working is mechanically modifying a metal below its recrystallization temperature, whereas hot working is mechanically modifying a metal beyond this temperature but below its melting or burning point[4]–[6].

Hot Working

Hot working refers to mechanical operations performed above the metal's temperature of recrystallization. While most industrial metals require some heating, some metals, like lead and tin, have low recrystallization temperatures and can be hot-worked even at ambient temperature. To avoid the metal burning and losing its usefulness, this temperature shouldn't be raised past the solidus temperature. The temperature at which metalworking is finished is critical when working with hot metals because any residual heat promotes grain development. This rise in grain size is a result of adjacent grains coalescing, and it depends on both time and temperature.

Poor mechanical qualities are a result of grain growth. If the hot working is finished just above the temperature of recrystallization, the resulting grain size will be acceptable. In order to ensure that the metal will remain slightly above and as close to its recrystallization temperature after the hot working procedure is over, the metal should be heated to a temperature that is lower than its solidus temperature.

Effect of Hot Working on Mechanical Properties of Metals

1. Typically, this procedure is carried out on a metal that has been kept at a temperature that prevents work-hardening. Some metals, such as Pb and Sn, can be hot worked at ambient temperature because of their low crystallization temperatures.
2. Increasing the metal's temperature reduces the stresses needed to cause deformations and broadens the range of deformations that can occur before severe work hardening occurs.
3. Hot working is desirable when significant deformations must be made but not primarily for work hardening purposes.
4. Cold working, annealing, and hot working all have the same overall effects on a metal.
    1. The metal is not strained or made harder.
5. Nonmetallic impurities are reduced in size and spread uniformly throughout the metal during hot working procedures, eliminating the need for massive, stress-inducing metal working masses. Compositional abnormalities are also eliminated.
6. Hot processes that improve grain structure include rolling. The mechanical properties of the component improve as the large columnar dendrites of cast metal are polished to smaller equi-axed grains.
7. Due to oxidation and scaling, the surface finish of hot worked metal is not nearly as good as with cold working.
8. The temperatures at which hot work is started and stopped must be carefully considered because they have an impact on the qualities that will be added to the metal after it has been hot worked.
9. A temperature that is too high may promote phase change and overheat the steel, whereas a temperature that is too low may cause excessive work hardening.
10. During hot working, metal flaws including blowholes, internal porosity, and cracks are eliminated or repaired.
11. Self-annealing and recrystallization take occurred during hot working just after plastic deformation. Through self-annealing, hardening and ductility loss are avoided.

Merits of Hot Working

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Demerits of Hot Working

1. Rapid oxidation or scale development and surface de-carburization on the metal surface occur during hot working due to the high temperature, resulting in a poor surface finish and metal loss.
2. The surface layer of the steel item being worked loses strength as a result of the carbon that has been removed from the surface. When the component is used, this presents a significant drawback.
3. The thinning of the surface layer can result in a fatigue crack, which might eventually cause the component to fail from fatigue.
4. Because some metals become brittle at high temperatures, they cannot be hot worked.
5. It is challenging to attain dimensional precision when hot working due to the thermal expansion of metals.

6. The process requires extra spending since tooling is so expensive. However, the greater production rate and superior component quality offset this.
7. Hot operating configurations can be challenging to handle and sustain.

Classification of Hot Working Processes

Following is a list of categories for hot working processes.

1. Hot rolling
2. Hot forging, and
3. Hot extrusion.
4. Hot forming of welded pipes
5. Tube forming
6. Hot drawing,
7. Hot spinning,
8. Hot piercing or Seamless tubing.

Principal Hot Working Processes

Hot Rolling

By using two or more rolls and plastic deformation caused by compressive stresses, rolling is the fastest way to shape metal into the required shape. Of all the methods for dealing with metal, it is one of the most frequently employed. The primary goal of rolling is to reduce bigger sections, like ingots, into smaller sections that can be used either immediately after rolling or as stock for other processes. The rolling process converts the cast ingot's coarse structure into a fine-grained one. The various mechanical qualities of rolled parts, such as toughness, ductility, strength, and shock resistance, have significantly improved. The majority of steel products are transformed from ingot form through the rolling process. The preparatory treatment given to the steel supplied in ingot form is the decrease in its section by rolling as illustrated in the figure. Figure 1 shows grain refinementin hot rolling process**.** Parts of the crystals are extended in the direction of rolling, and after leaving the stress zone, they begin to reform. Many important items, including rails, sheets, structural sections, and plates, are produced using the hot rolling method[7]–[9].

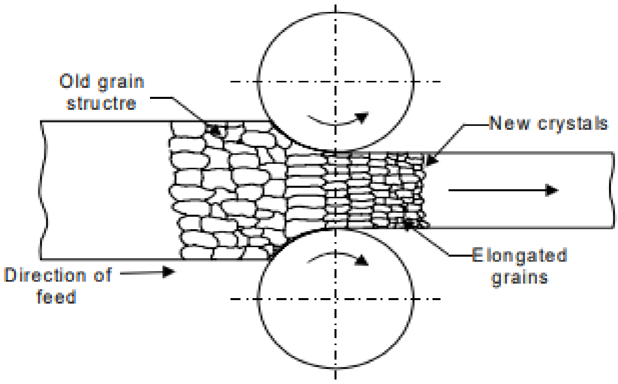

Figure 1: Shows grain refinement in hot rolling process (wordpress.com).

Two-High Rolling Mill

Two horizontal rolls in a two-high rolling mill rotate at the same speed but in the opposite direction. The rolls are held in place by bearings that are contained in strong, upright side frames known as stands. The higher roll can be raised or lowered to change the distance between the rollers. They rotate in a set direction that cannot be changed. The reduction in work thickness is accomplished by just feeding in one direction. However, there is a different kind of two-high rolling mill that has a drive system that allows the rolls to rotate in the opposite direction. Continuous rolling of the workpiece occurs in a two-high reversing rolling mill through back-and-forth passes between the rolls.

Three- High Rolling Mill

It is made up of three parallel rolls that are stacked one over the other. The intermediate roll rotates in a direction that is opposed to both the upper and lower rolls' directions of rotation. Without switching the drives around, this kind of rolling mill is utilized to roll two continuous passes in a rolling sequence. As a result, production is increased in comparison to the two-high rolling mill.

Four- High Rolling Mill

It is essentially a rolling mill with two levels, but it has smaller rolls. Practically speaking, it consists of four horizontal rollers the top and bottom rolls are larger than the two middle rolls. Working rolls are those that are smaller in size and concentrate the total rolling pressure over the workpiece. The bigger diameter rolls are known as backup rolls, and their principal purpose is to stop the smaller rolls from deflecting, which would otherwise cause the center of rolled plates or sheets to thicken. These mills typically produce hot- or cold-rolled plates and sheets.

Cluster Mill

It is a particular kind of four-high rolling mill each of the two smaller working rolls is supported by two or more of the larger back-up rolls. It may be required to use work rolls with a very tiny diameter yet a significant length when rolling hard, thin materials.Figure 2 shows hot rolling stand arrangementsIn these circumstances, a cluster-mill can be used to achieve enough support for the working rolls. Typically, this kind of mill is utilized for cold rolling activity.

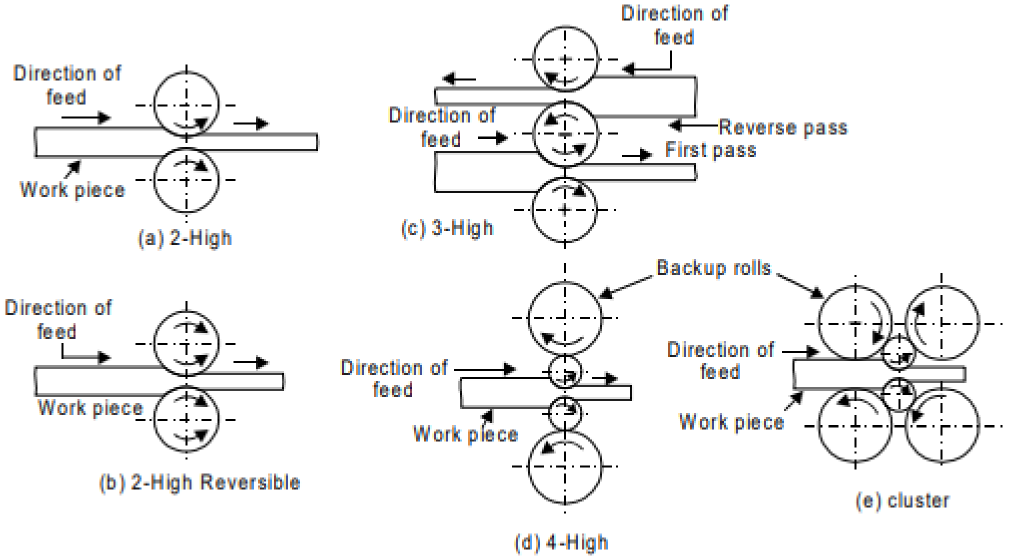

Figure 2: Shows hot rolling stand arrangements (wordpress.com).

Continuous Rolling Mill

It is made up of a number of two-high, non-reversing rolling mills that are stacked one after the other so that the material can be run through each one in turn. It is only appropriate for tasks involving mass manufacturing, as quick setup adjustments for lesser quantities would be necessary and take up a lot of time and labor.

Applications of Rolling Mill

The more substantial rails and structural parts are produced at the rail mill. Girders, channels, angle irons, and tee-irons are made in rolling mills. Figure 3 shows Hot Rolling Stand Arrangements.Rolling plates from slabs in a plate mill. The materials that are frequently hot rolled include a variety of steel grades, copper, magnesium, and aluminum.

Hot piercing or Seamless Tubing

Hot piercing is also referred to as roll piercing or seamless tubing. Round shapes with thin walls are created using it. In compared to machining, seamless tube forming is a popular and cost-effective procedure because it avoids material waste from part boring.Hot piercing uses rotary piercing, which involves inserting a pointed mandrel through a billet in a specially made rolling mill, to create formed tubes. Either a two-high rolling mill or a three-high rolling mill can be used for the rotational piercing. In the former, the two rollers are positioned at an angle. Due to tensile strain, the billet beneath the rolls deforms and a cavity development is started at the center. The mandrel's finely contoured shape aids and regulates cavity formation. The three shaped rolls are positioned at 1200 in a rolling mill with three levels, and their axes are inclined at a feed angle to allow the billet to go forward and rotary. The billet is compressed and bulged, which creates a seam in the center of the billet and results in a rather thick-walled tube. This tube is then again passed over a plug and through grooved rolls in a two-high roll mill, where the thickness is reduced and the length is increased. It is transferred to a reeling machine, which has two rollers similar to the piercing rolls but with flat surfaces, while it is still warm. Run it through sizing dies or rolls for greater precision and a finer finish. The scale is removed from the tubes using a pickling bath of diluted sulfuric acid once they have cooled[10]–[12].

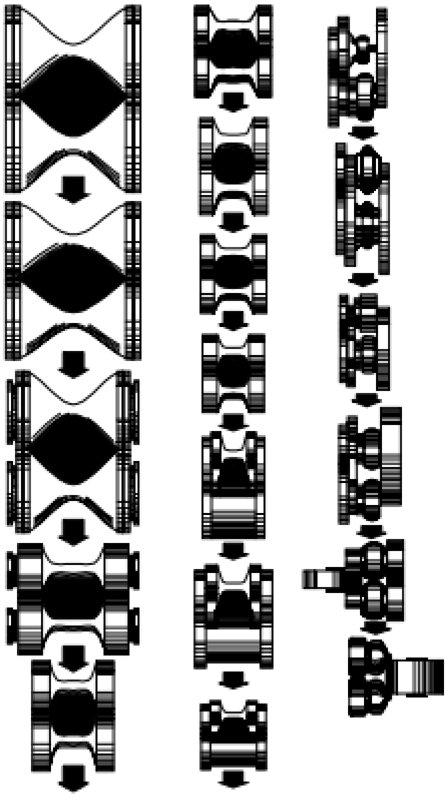

Figure 3: Shows Hot Rolling Stand Arrangements(wordpress.com).

CONCLUSION

Metal forming requires the hot working of metals, which has significant advantages and broad uses across numerous sectors. It is simpler to shape and deform metals because of their enhanced ductility due to the hot working's elevated temperatures. In addition, compared to cold working techniques, hot working requires less forming force, which results in cheaper energy consumption and manufacturing costs. Improvements in strength, toughness, and grain refinement can all be attributed to the microstructural modifications that take place during hot working. In order to achieve the best results, hot working must be carefully handled to avoid problems like oxidation, grain growth, and thermal stresses. To get the desired material properties and prevent flaws, it is essential to choose and regulate process factors including temperature, strain rate, and deformation procedures properly.

REFERENCES

[1] L. Anand, "Constitutive equations for hot-working of metals," *Int. J. Plast.*, 1985, doi: 10.1016/0749-6419(85)90004-X.

[2] S. B. Brown, K. H. Kim, and L. Anand, "An internal variable constitutive model for hot working of metals," *Int. J. Plast.*, 1989, doi: 10.1016/0749-6419(89)90025-9.

[3] Y. C. Lin and X. M. Chen, "A critical review of experimental results and constitutive descriptions for metals and alloys in hot working," *Materials and Design*. 2011. doi:

10.1016/j.matdes.2010.11.048.

[4] T. R. McNelley, S. Swaminathan, and J. Q. Su, "Recrystallization mechanisms during friction stir welding/processing of aluminum alloys," *Scr. Mater.*, 2008, doi: 10.1016/j.scriptamat.2007.09.064.

[5] C. Liu, "Modeling of water and lubricant sprays in hot metal working," *ProQuest Diss. Theses*, 2007.

[6] M. O. Bodunrin, "Flow stress prediction using hyperbolic-sine Arrhenius constants optimised by simple generalised reduced gradient refinement," *J. Mater. Res. Technol.*, 2020, doi: 10.1016/j.jmrt.2019.12.070.

[7] F. Montheillet, D. Piot, N. Matougui, and M. L. Fares, "A critical assessment of three usual equations for strain hardening and dynamic recovery," *Metall. Mater. Trans. A Phys. Metall. Mater. Sci.*, 2014, doi: 10.1007/s11661-014-2388-9.

[8] Y. V. R. K. Prasad and N. Ravichandran, "Effect of stacking fault energy on the dynamic recrystallization during hot working of FCC metals: A study using processing maps," *Bull. Mater. Sci.*, 1991, doi: 10.1007/BF02744618.

[9] L. H. S. Luong and T. Heijkoop, "The influence of scale on friction in hot metal working," *Wear*, 1981, doi: 10.1016/0043-1648(81)90142-3.

[10] S. V. S. Narayana Murty, B. Nageswara Rao, and B. P. Kashyap, "On the hot working characteristics of 6061Al-SiC and 6061-Al2O3 particulate reinforced metal matrix composites," *Compos. Sci. Technol.*, 2003, doi: 10.1016/S0266-3538(02)00197-5.

[11] M. Massicotte, G. Soavi, A. Principi, and K. J. Tielrooij, "Hot carriers in graphene-fundamentals and applications," *Nanoscale*. 2021. doi: 10.1039/d0nr09166a.

[12] N. S. Saadi, L. B. Hassan, and T. Karabacak, "Metal oxide nanostructures by a simple hot water treatment," *Sci. Rep.*, 2017, doi: 10.1038/s41598-017-07783-8.

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UNDERSTANDING THE INDUSTRIAL SAFETY

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ABSTRACT

Ensuring industrial safety in the manufacturing industry is of crucial significance to protect employees, avoid accidents, and maintain a productive and healthy work environment. This summary gives an overview of essential factors and solutions for boosting industrial safety in the manufacturing business. Industrial safety comprises a broad variety of procedures and methods meant to detect, avoid, and reduce hazards connected with industrial processes and equipment. It entails building a safety culture, adopting proper safety rules, offering training and education, and performing frequent inspections and audits. Effective industrial safety management starts with developing a culture of safety across the business. This comprises promoting safety as a fundamental value, fostering open discussion about possible dangers, and enabling workers to actively engage in safety activities. When safety becomes an intrinsic part of the corporate culture, it greatly minimizes the chance of accidents and injuries.

KEYWORDS: *Accidents, Employees, Industrial, Safe, Safety.*

INTRODUCTION

In all sorts of businesses, each shop supervisor is typically given the duty of safety in his workplace regarding the employees, machinery and materials. Every supervisor in each shop ensures to the senior executives in regard of all types of the safety concerns. He is obliged to incorporate any new safety measures needed in the shop from time to time. With the growth in the scale of the company and depending upon the hazardousness of industrial operations, a full-fledged safety department should be developed under the intense supervision via a safety manager. The safety manager may be granted a line position or staff role depending upon the working circumstances in the business. Sometimes the duty for safety lies on a safety committee constituted by the senior executives of the business. A safety committee may consist of executives, supervisors, and shop floor employees. Thus, the lower-level workers get a channel of communication on safety problems straight to executive level.

It is a matter of fact that those organizations who created safety committees had lower record of accidents than those without safety committees. Safety committees constantly urge all the industrial employees for growing safety awareness. It works also as a policy making body on safety matters. To boost the effectiveness of the safety committee, certain safety issue may be assigned to safety staff for establishing and executing safety regulations and publicizing them. Its members should be invited to go on the shop floor and observe what is being done there until date about the safety measures. It should be requested to report routinely as what improvements have been achieved and what more can be done for safety aspects in near future for avoiding any mis-happening in the plant. Safety committee typically prepares safety programs to make industrial personnel properly vigilant for overall safety inside the facility.

A safety program tends to uncover when, where and why accidents occur. It constantly focuses at decreasing accidents and the losses linked with them. It starts with the notion that more work-connected accidents may be averted. It does not have an end rather it is a continual process to achieve appropriate safety. It comprises giving, safety devices and particular training to employees. It consists of support by top management, appointing a safety officer, engineering a safe plant, processes and operations, educating all industrial employees to work safely, studying and analyzing the accidents to prevent their occurrence in future, holding safety contests, safety weeks etc., and awarding incentives or special prizes to departments which enforces the safety rules and having least number of accidents[1]–[3].

A safety plan should always comprise engineering safety at the design and equipment installation stage, education of staff in safe procedures, concerns the attitude of employees and management. It should inspire all the industrial staff in accident prevention and safety awareness. It must give all safety instructions and training required for the employees to think, behave and operate safely so that the number of accidents may be avoided.

Safety education must teach information about safe and harmful mechanical circumstances and personal behaviours. Safety training must entail induction and orientation of new recruits to safety regulations and practices, explaining safety function, during their first work training through efforts made by the first level supervisors. Formulating employee's safety committees, holding of employee's safety meeting, exhibition of charts, posters, video etc. are very much vital in each sector for emphasising the necessity to behave safely. It trains workers to improve theirsafety awareness. An industrial worker will typically accept the implementation of a safety precaution if he is persuaded of its importance. Therefore, relevant measures must be established to improve the awareness of a need for safety in the environment of work. Such steps are essential in an industrial organization to create safety awareness among workers or other personnel. There should be adequate display of safety posters and videos from time to time to remind industrial employees to specific hazards/accidents, offering simple and easy safety equipment, allowing time to the worker for setting, removing and replacing any necessary safety devices. All industrial people should be asked from the first day to start working to implement safety measures since an untrained worker needs be acquainted completely to operate safely.

A safety committee should administer regular safety activities that may organise safety competitions. Award and prizes are also to be presented to the winners for imparting proper respect and recognition to safe workers and generate in employees a sense of pride in safe work. It should expand on the safety theme till all the staff are safety cognizant. It must hold frequent safety meetings and develops the safety concepts in industrial personnel for being more safety concerned. It must ask the shop supervisor to exhibit all the safety elements near the work centre. It should also send safety information and adequate material relevant to safety for reading at residences of all the industrial personnel. It must accept any safety suggestions. It must designate unequivocally all accident places. It must perform safety training lectures frequently for delivering broad publicity to safety elements for everything including men, machines and materials.

DISCUSSION

Planning For Industrial Safety

Mis-happening of a huge number of fire dangers, accidents, industrial catastrophes etc., may be reduced to the smallest feasible amount by rigorous safety planning inside an industrial organization. All these unpleasant incidents may be averted by good planning for safety.Safety consideration includes proper layout of buildings and equipment, such as providing adequate ventilation, sufficient working area to the operator, clear pathways for movement of materials and parts, provision for adequate personnel facilities- viz., canteens, lunch rooms, dispensary, fire fighting services, etc. Careful preparation in advance for efficient and safe layout of design and manufacturing operations for industry provides industrial safety in the production and inventory domains. Incorporating safety concerns well in time are helpful for the development of a new plant as well as an existing plant requiring major alterations. Such factors lead to acceptable safety to employees, machine and equipments, reduction in operating time and rise in productivity. Several rules and standards for industrial safety, health and hygiene, fire prevention, etc. have been prescribed by government and other safety bodies and they should be completely taken care of during the design and implementation phases of a facility. A number of critical factors should be examined and suitably included designing the layout of a new facility and its structures for safety. Hoists and conveyors are extensively employed in industries for lifting, lowering and transferring loads over limited distances. A high degree of safety is essential when these machines are in operation[4]–[6].

During operations of these machines, one should bear in mind the following important safety precautions. Material handling and its storage are fairly prevalent operations in a factory. Material handling when handled manually the possibilities of injury are larger. Therefore the following points should be taken care for carrying out such duties. All material handling devices such as conveyers, automobile guided vehicles, robots, cranes should contain suitable protection for its gears and other hazardous moving elements to prevent access from these parts during operation. Allhoisting devices must be provided with limit switches for avoiding loads block from over traveling inadvertently. Hoisting equipment notably cranes, should only be used by properly trained individuals for preventing all types of errors or accidents. While operating a crane, the operator should be totally led by standard signal and both operator and his signaler should be well taught. Proper safeguards against fire and explosion threats are required when gasoline driven crains are being employed. Where manual loading is done on conveyors which travel along a vertical route, either partly or entirely, safe load sign should be prominently placed on all loading stations. Sufficient lighting, ventilation, drainage, escape ways and security should be provided for conveyors which operate in pits, tunnels and similar other enclosures. Riding on a conveyor should always be forbidden. All the personnel working on or near the conveyor must wear tight clothes and safety shoes. All revolving, reciprocating and projecting elements of machinery and equipments such as sprockets, gears, etc., should be adequately secured by suitable guarding. An efficient lubrication schedule should be worked out and executed. All examination should be carried out frequently and worn out components, if any, should be replaced promptly.

The personnel should be appropriately instructed to adopt safe working practises and sufficient supervision should be done when these activities are being carried out manually. Industrial personnel and unskilled employees should be appropriately taught for adopting safe working habits in the proper techniques of raising and putting down the products. They should be instructed to be wary from pinches and shear points and to hold the things firmly while lifting or putting down. Objects which are moist or unclean or have slippery surfaces, such as greasy or oily and wet products should be entirely cleaned off dry before touching them. The hands should also be kept clean of oil and grease. For avoiding hand injuries the handlers should be compelled to wear protective clothing like leather hand gloves, sleeves, etc. The worker handling materials should always wear foot in order to avoid foot injuries. If an item is to be lifted and transported to some distance it should be assured that the route is not slippery and there are no obstructions on the passage or road. The unskilled industrial workers should be properly trained for keeping correct positions of their feet, positions of back and knees, holding the object close to the body while lifting and carrying, correct and firm grip, position of chin and application of body weight in lifting and setting down by hand. This will assist to avoid muscular strains and back issues. When a gang or team of employees is utilised to move a large load from one place to another the supervisor should oversee the use of correct equipment and direct the work himself to ensure perfect synchronization in the lifting, walking and putting down activities of all the workers involved. While transporting goods by trucks, the vehicle should be operated at safe limit speed as stipulated and extra attention should be given at blind corners and doors.

During storing material, it should be assured that the electrical panels and installations and fire extinguishers and hoses are maintained clear and have easy accessibility. Also the pathways, entries and exits should always be maintained clean for mobility. The use of racks and bins enables additional storage capacity, simple transfer of goods from one location to another and ensures improved safety in an industrial organization.

Objectives of Industrial Safety

1. Industrial safety is essential to check all the probable risks of accidents for preventing loss of life and permanent handicap of any industrial employee, any damage to machine and material as it leads to the loss to the complete business.
2. It is important to eliminate accidents resulting work stoppage and output loss.
3. It is important to avoid accidents in industry by decreasing any danger to minimal.
4. It is important to lower workman’s compensation, insurance rate and all the expense of accidents.
5. It is important to educate all members with the safety rules to prevent accidents in business.
6. It is important to develop greater morale of the industrial workforce.
7. It is necessary to establish stronger human interactions inside the sector.
8. It is important to expand production means to a better level of life.

Accidents and their types

There are different sorts of frequent accidents demanding proper attention to avoid them which are as follows:

1. Near Accident

An collision with little damage or injuries is termed near accident.

2. **Trivial**

An accident with very limited damage is considered trivial.

3. **Minor Accident**

It is an accident involving damage and injuries greater than insignificant.

4. **Serious Accident**

An accident involving severe damage and plenty of harm is termed major accident.

5. **Fatal**

It is an accident with quite significant damage. There may be loss of life as well.

Effect of Accidents

The detrimental impacts of the accident are indicated as beneath-

a. Effect on the owner of factory

(i) Direct cost of an accident

a. Cost of the compensation given to the employees.
b. Cost of the money spent for therapy.
c. Cost of the monetary worth of damaged tools, equipment's and materials.

(ii) Indirect cost of an accident

a. Cost of the lost time of wounded worker.
b. Cost of the time missed by other workers.
c. Cost of the delays in manufacturing.
d. Cost of the time wasted by supervisors, safety engineers etc.
e. Cost of the diminished production due to replacement worker.

b. Effect on worker

1. The industrial employees may obtain temporary or permanent impairment.
2. If the industrial worker dies, his family loses the earner and the compensation never equals to his wages.
3. Accident also impacts the morale of the people working in the manufacturing environment.

c. Effect on society

1. Cost of accidents is incorporated in the goods, thus the society has to pay extra prices for the industrial items.
2. If certain industrial employees do not fall under compensation statute, the necessity for support from society is significantly bigger.
3. Loss of manufacturing hours may causes less items in market. So greater prices if demand is larger than output.

Common Sources of Accidents

A huge number of revolving, rotating, reciprocating and moving elements of equipment may be said as the sources of hazard and need guarding for protection against accidents. Extensive studies demonstrate that several typical groupings of harmful components are serving as common sources of accidents in workplaces. Many such prominent sources are as beneath.

1. Revolving components, viz. pulley, flywheels, worms, worm wheel, fan, gears, gear trains, gear wheels etc.
2. Projecting fasteners of rotating components; as bolts, screws, nuts, key heads, cotters and pins etc.
3. Intermittent feed mechanisms, viz., tool feed of planer; table feed of a shaper, ram feed of power presses and similar other applications.
4. Revolving shafts, spindles, bars, mandrels, chucks, followers and tools like drills, taps, reamers, milling cutters, and boring tool etc.
5. Rotating worms and spirals encased in casings, such as in conveyors and revolving cutting tool, including milling cutters, circular saw blade, saw band, circular shears and grinding wheels, etc.
6. Reciprocating tools and dies of power presses, spring hammer, drop hammers, and reciprocating presses, reciprocating knives and saw blade such bow saw, shearing and perforating machines and the cutting and trimming machine and power hacksaws etc.
7. Moving components of different equipment, such those of printing machines, paper-cutters and trimmers, etc.
8. Revolving drums and cylinders without casing, such as concrete and other mixers, tumblers and tumbling barrels, etc.
9. High speed spinning cages such as in hydro-extractors.
10. Revolving weights, such as in hydraulic accumulator or in slotting machines for counter-balance.
11. Nips between meshing racks and pinions of machine components
12. Nips between reciprocating parts and stationary components, such as between shaper table and the fixture attached on it or a planer table and table reversing stops, etc.
13. Nips between crank handles for machine controls and fixed components
14. Projecting nips between different connections and mechanisms, such cranks, connecting rods, piston rods, revolving wheels and discs, etc.
15. Projecting sharp edge or nips of belt and chain drives; through belt, pulleys, chains sprockets and belt fasteners, spiked cylinders etc.
16. Nips between revolving control handles and stationary components traverse gear handles of lathes, millers, etc.
17. Moving balance weights and dead weight, hydraulic accumulators, counter-balancing weight on big slotting machines, etc.

18. Revolving drums and cylinders uncased, tumblers in the foundry, mixers, varnish mixers etc.
19. Nips between fixed and moving elements such as buckets or hoppers of conveyors against tipping bars, stops or sections of the structure.
20. Nips between spinning wheels or cylinders and pans or tables, sand mixers, crushing and incorporating mills, mortar mills, leather carrying machines, etc.
21. Cutting edges of limitless band cutting machines, wood working, and log cutting metal discover stone-cutting band saws, cloth-cutting band knives, etc.
22. Nips between gears and racks strips, roller drives, presses, planning machine drives, etc.

Preventive Measures

Few safety measures commonly used in industries comprise of the proper safety guards for reciprocating machine components such as drop hammers, presses, shaper, slotter, power hacksaw, paper cutters etc., fencing of dangerous and rotating parts like revolving shafts, incorporating safety devices such as safety valves, rigid construction of heavy items like hoists, cranes etc, proper insulation of electric wire and earthing of electric appliances, wearing appropriate safety shoe and other necessary items for, body protection, maintenance cleanliness of shop floor, removal of metal chips with proper protection, avoiding fire hazard [7]–[9].

Safety when working safely in any shop is the safety of human being and the safety of workshop equipment. Hence there is a huge demand for the study of the subject of industrial safety for accidents avoidance and proper house keeping is the foremost. Safe working conditions in any sector may assist to decrease the number of accidents taking place, avoid premature death of talented employee, prevent unnecessary pain and suffering to industrial employees, reduce damages to equipment and machinery, boost output and lower production cost.

Good housekeeping entails keeping industry clean, seem nice properly lighting and ventilated so that accidents are avoided, overall output and quality are increased and the employee morale is raised. Careless handling of heavy objects and components is a significant source of back and foot injuries. To reduce early weariness of transport employees, maximum use should be made of mechanical materials handling equipment. Use mechanised methods of transportation to ensure the safety of personnel involved in material handling.

The transport employees should not be asked to lift more than the authorised load. Personal protective items such as safe hard hats, rubberized hats for protection against liquids /chemicals, ear protectors, face mask/facial shields, welding helmet, goggles of case-hardened and transparent glass for protection against impact should be worn as per the demand.The excellent housekeeping has been borrowed from the management of domestic properties in the home or house and is now freely used to the maintenance of both cleanliness and order in all sorts of commercial enterprises, e.g., factories etc. Cleanliness is a condition wherein buildings, work and rest places, machinery, equipments and tools are maintained free from dirt, dust etc[10], [11].

Necessity of excellent housekeeping is required in order to create and maintain a clean and tidy industrial operate in its surroundings. It makes work more pleasurable, more satisfying and motivating for every sort of workers to work. The benefits of proper house maintenance are fewer accidents, greater life of building, equipment, tools, etc., higher staff morale, enhanced output, better product quality, continual cleaning decreases housekeeping costs, no time is spent in looking for tools etc, material handling and transportation pick up speed, inspection, maintenance and production control functions become simpler, much floor space otherwise occupied by unused raw material and tools. A good home keeping technique involves plan and project the cleaning program attentively and completely

CONCLUSION

Improving industrial safety in manufacturing needs a holistic strategy that incorporates a safety-focused culture, rigorous safety standards, constant training and education, thorough inspections and audits, and the incorporation of technology. By addressing safety, firms can safeguard their most precious asset their employees and create a productive and sustainable work environment. With continued dedication and investment in safety standards, the manufacturing sector may constantly aim towards decreasing workplace mishaps and increasing the well-being of its employees.

REFERENCES

[1] W. Pantleon and P. Klimanek, "Modelling the hot-working behaviour of metals," *Comput. Mater. Sci.*, 1994, doi: 10.1016/0927-0256(94)90136-8.

[2] X. ting Zhong, L. Ke Huang, L. Wang, F. Liu, X. Ming Dong, And Z. Hua Zhang, "A Discontinuous Dynamic Recrystallization Model Incorporating characteristics of initial microstructure," *Trans. Nonferrous Met. Soc. China (English Ed.*, 2018, doi: 10.1016/S1003-6326(18)64874-5.

[3] S. F. Wong, P. D. Hodgson, C. J. Chong, and P. F. Thomson, "Physical modelling with application to metal working, especially to hot rolling," *J. Mater. Process. Technol.*, 1996, doi: 10.1016/0924-0136(95)02219-8.

[4] S. Kahmann and M. A. Loi, "Hot carrier solar cells and the potential of perovskites for breaking the Shockley-Queisser limit," *Journal of Materials Chemistry C*. 2019. doi: 10.1039/c8tc04641g.

[5] A. P. Manuel and K. Shankar, "Hot electrons in TiO2–noble metal nano-heterojunctions: Fundamental science and applications in photocatalysis," *Nanomaterials*. 2021. doi: 10.3390/nano11051249.

[6] S. V. S. Narayana Murty, B. Nageswara Rao, and B. P. Kashyap, "On the hot working characteristics of 6061Al-SiC and 6061-Al2O3 particulate reinforced metal matrix composites," *Compos. Sci. Technol.*, 2003, doi: 10.1016/S0266-3538(02)00197-5.

[7] M. Massicotte, G. Soavi, A. Principi, and K. J. Tielrooij, "Hot carriers in graphene-fundamentals and applications," *Nanoscale*. 2021. doi: 10.1039/d0nr09166a.

[8] N. S. Saadi, L. B. Hassan, and T. Karabacak, "Metal oxide nanostructures by a simple hot water treatment," *Sci. Rep.*, 2017, doi: 10.1038/s41598-017-07783-8.

[9] E. Elhachmi, "Tool steels," in *Steel Heat Treatment: Metallurgy and Technologies*, 2006. doi: 10.31399/asm.tb.spsp2.t54410621.

[10] S. V. S. Narayana Murty, B. Nageswara Rao, and B. P. Kashyap, "On the hot working

characteristics of 2124 Al-SiCp metal matrix composites," *Adv. Compos. Mater. Off. J. Japan Soc. Compos. Mater.*, 2002, doi: 10.1163/156855102760410315.

[11] M. Bambach *et al.*, "On the hot deformation behavior of Ti-6Al-4V made by additive manufacturing," *J. Mater. Process. Technol.*, 2021, doi: 10.1016/j.jmatprotec.2020.116840.

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A STUDY ON COMPONENTS OF LATHE MACHINE

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ABSTRACT

A flexible and necessary instrument for shaping, cutting, and turning materials including wood, metal, and polymers is the lathe machine. An overview of the lathe machine's functionality and importance in manufacturing processes is given in this abstract. It shows the various varieties of lathe machines and their uses, as well as the essential elements and tasks related to the lathe machining procedure. The abstract also mentions improvements in lathe machine technology and how they have affected contemporary industry. Overall, the purpose of this abstract is to highlight the significance of the lathe machine as a key instrument in the manufacture of complex and accurate components.

KEYWORDS: *Chuck, Feed, Job, Lathe, Taper, Tool.*

INTRODUCTION

One of the most adaptable and popular machine tools in use today is the lathe. It is frequently referred to as the mother of all machine tools. A lathe's primary purpose is to remove metal from a project in order to shape and size it as needed. The position is stable, and turning it against a single point cutting tool will remove metal from the project in the form of chips while it is rigidly held in the chuck or between centers on the lathe machine. The operation of a lathe is demonstrated in Figure 1. The most fundamental and basic type of lathe is an engine lathe. It gets its name from the early lathes, which used engines for power. A lathe can be used for a variety of operations in addition to the straightforward turning action described above, including drilling, reaming, boring, taper turning, knurling, screwthread cutting, grinding, etc.

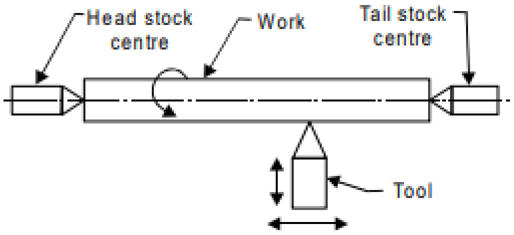

Figure 1:Shows working principle of lathe machine (wordpress.com).

Types of Lathe

From very small bench lathes used for precision work to enormous lathes used to turn gigantic steel shafts, lathes come in a range of styles and sizes. However, all types of lathes operate and function according to the same principles. The various kinds of lathes are:

1. Speed lathe
(a) Wood working
(b) Spinning
(c) Centering
(d) Polishing
2. Centre or engine lathe
(a) Belt drive
(b) Individual motor drive
(c) Gear lathe
3. Bench lather
4. Tool room Lathe
5. Capstan and Turret lathe
6. Special purpose lathe
(i) Wheel lathe
(ii) Gap bed lathe
(iii) Duplicating lathe
(iv) T-lathe
7. Automatic lathe.

Speed Lathe

The construction and use of the speed lathe is the simplest of all lathe types. The following are speed lathe's crucial components:

Bed, Headstock, Tailstock, and Tool Post installed on an Adjustable Slide are the first three components. It lacks a feed box, a lead screw, and a typical carriage. The tool is positioned on the movable slide and manually fed into the job. Where cutting force is little, such as in woodworking, spinning, centering, polishing, winding, buffing, etc., the speed lathe finds use. The headstock spindle of this lathe spins at an extremely fast speed, hence its name[1]–[3].

Centre Lathe

This lathe is known as an "engine" because a steam engine powered it during the very early stages of its development. The most utilized and significant member of the lathe family is this one. The engine lathe has all the fundamental components, such as a bed, headstock, and tailstock, just like the speed lathe. Its headstock, however, is built considerably more solidly and has an additional mechanism for operating the lathe spindle at various speeds. An engine lathe is seen. In contrast to the speed lathe, the engine lathe uses a carriage, feed rod, and lead screw to feed the cutting tool both transversely and longitudinally with respect to the lathe axis. Depending on how power is delivered to the machine, center lathes and engine lathes are divided into different categories. The power can be transferred using a belt, an electric motor, or gears**.**

Bench Lathe

This is a little lathe that is often bench-mounted. It performs nearly all the functions of an engine lathe or speed lathe and has almost all of its components. Figure 2 shows principal components of a center lathe.This is utilised for precise, tiny tasks.

Tool Room Lathe

Although this lathe is much more precisely constructed, it has many characteristics with engine lathes. Its spindle speeds range widely, from a very low speed to a very high speed of up to 2500 rpm. This lathe is mostly used for accurate machining tasks that need precision work on tools, dies, and gauges.

Capstan and Turret Lathe

These lathes were created as a result of the technological evolution of the engine lathe and are extensively utilized for jobs requiring large manufacturing. The distinctive characteristic of this kind of lathe is that the engine lathe's tailstock is replaced by a hexagonal turret, on whose face several tools may be mounted and fed into the work in the appropriate order. Due to this structure, several operations of various sorts can be performed on a task without resetting work or tools, and many identical parts can be produced in the shortest amount of time.

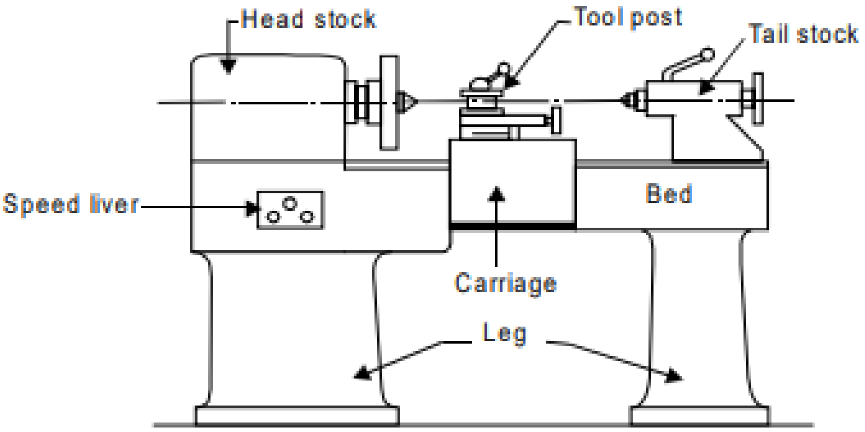

Figure 2: Shows principal components of a center lathe (wordpress.com).

Special Purpose Lathe

These lathes are made for specialized tasks and jobs that can't be easily or comfortably done on a regular lathe. The wheel lathe is designed for using on railway car and locomotive wheels to polish the journals and turn the tread the void. Extra-large diameter components are swung on a bed lathe, which has a removable segment of the bed near the headstock. Rotors for jet engines are machined on a T-lathe. This lathe's bed is T-shaped. A replicating lathe is used to transfer the shape of a flat or rounded template to the workpiece[4]–[6].

Automatic Lathe

These lathes are made in such a way that the entire production process for a task, including all job management and working movements, is automated. These lathes are fully automatic, heavy duty, high speed, mass production lathes.

DISCUSSION

Construction of lathe machine

These lathes are made in such a way that the entire production process for a task, including all job management and working movements, is automated. These lathes are fully automatic, heavy duty, high speed, mass production lathes.Figure 3 shows different parts of engine lathe or central lathe

1. Bed
2. Head stock
3. Tailstock
4. Carriage
5. Feed mechanism
6. Thread cutting machine.

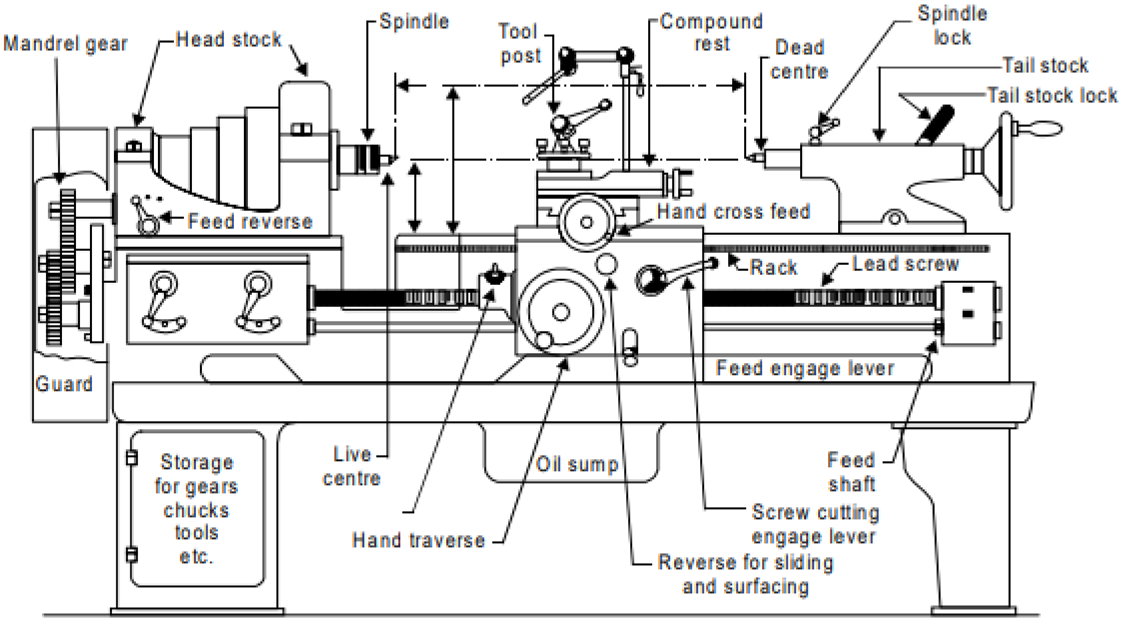

Figure 3: Shows different parts of engine lathe or central lathe (wordpress.com).

Bed

All other components of a lathe machine are positioned on top of the bed. It is a single, massively rigid casting that serves as support for the lathe's other operational components. The headstock of the lathe machine is placed on the left end of the bed, while the tailstock is on the right side. The machine's carriage moves across the bed and rests there. There are two sets of guide ways inner and outer on the top of the bed. The tailstock has sliding surfaces on the inner ways, whereas the carriage has sliding surfaces on the outer ways. The lathe bed's guide ways might have a flat or inverted V form. The lathe bed is typically made of cast iron alloyed with nickel and chromium material.

Head Stock

Power transmission to the various components of a lathe is the major job of the headstock. It includes the headstock casting, which has room for all the pieces inside, including the gear train arrangement. It is adjustable to hold the main spindle, which has a live center on which the work can be attached. Fitted inside the headstock's main spindle, it supports the work and revolves with it. This setup also includes a cone pulley, which is used to control the spindle speed of an electric motor. For a variety of slower speeds, the back gear arrangement is used. Change wheels are a type of gear used to provide the various velocity ratios needed for thread cutting.

Tail Stock

The central lathe's tail stock, which is frequently utilized to hold the circular job being turned on centers and principally provide an outside bearing, is depicted in Figure.4. The tail stock has a dead center that supports one end of the work and may be readily set or changed for alignment or non-alignment with respect to the spindle center. The 60° conical points on both live and dead centers fit the circular job's center holes, while the other end tapers to provide for a good fit into the spindles. To prevent friction between the work and the dead center, which is crucial for holding large jobs, the dead center can be installed in a ball bearing.

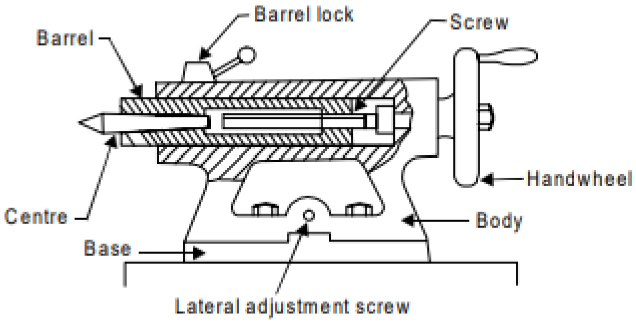

Figure 4: Shows tail stock of central lathe (wordpress.com).

Carriage

The carriage is fixed to the lathe bed's outside guide ways and is capable of moving in a direction perpendicular to the spindle axis. Important components include the apron, cross-slide, saddle, compound rest, and tool post. The name "apron" refers to the lower portion of the carriage where gears are used to create an apron mechanism that adjusts the direction of the feed using a clutch mechanism and a split half nut for automatic feed. In essence, the cross-slide is positioned on the carriage. The carriage, which typically moves at a right angle to the spindle axis, is basically where the cross-slide is placed. An adjustable saddle that may spin and fix to any desired angle is fitted on the cross slide for the compound rest. Using a screw that revolves in a nut fastened to the saddle, the compound rest slide is moved[7]–[9].

The tool post, which attaches to the carriage through the tool post screw and slides into a tee-slot in the compound rest, is a crucial component. The tool post of the centre lathe is shown in Figure 5.

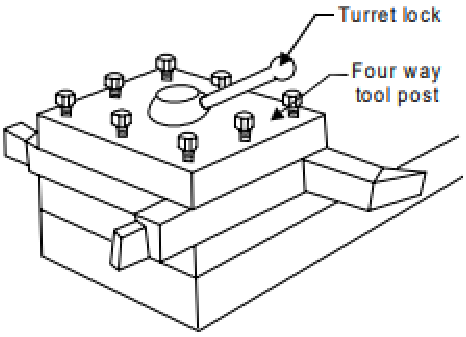

Figure 5: Shows tool post of central lathe (wordpress.com).

Feed Mechanism

The carriage is fixed to the lathe bed's outside guide ways and is capable of moving in a direction perpendicular to the spindle axis. Important components include the apron, cross-slide, saddle, compound rest, and tool post. The name "apron" refers to the lower portion of the carriage where gears are used to create an apron mechanism that adjusts the direction of the feed using a clutch mechanism and a split half nut for automatic feed. In essence, the cross-slide is positioned on the carriage. The The feed mechanism, which consists of a number of various components, is how the headstock spindle's motion is transferred to the lathe machine's carriage. The following components are involved in a lathe machine's feed mechanism.

1. End of bed gearing
2. Feed gear box
3. Feed rod and a lead screw
4. Apron system

The feed gear box receives the headstock spindle's rotating motion through the gearing at the end of the bed. Depending on whether the lathe machine is being used for simple turning or screw cutting, the motion is further transmitted through the feed gear box to either the feed shaft or lead screw. Numerous gears of various sizes are present in the feed gear box. By adjusting the rotational speed of the feed rod or lead screw, the feed gear box offers a way to adjust the rate of feed as well as the ratio between headstock spindle revolutions and carriage movement for thread cutting. The saddle is fitted with the apron. The feed rod is connected to the carriage by gears and clutches, and the half nut that engages with the lead screw to cut threads is also inside.

Thread Cutting Mechanism

In a lathe, the split or half nut is used to cut threads. It locks or unlocks the carriage's connection to the lead screw, allowing the tool to move over the workpiece to cut screw threads as the lead screw rotates. The location of the feed reverse lever on the headstock determines which way the carriage moves.

Accessories and attachments of lathe

The lathe maker includes a variety of lathe accessories with the lathe to support lathe operations. Centers, catch plates and carriers, chucks, collets, face plates, angle plates, mandrels, and rests are a few of the crucial lathe components. These can be used to hold the tool or to support and hold the work. Attachments are extra pieces of equipment that come with the lathe and can be utilized for particular tasks, according to the lathe maker. The lathe attachments include crank pin turning attachments, stops, ball turning rests, thread chasing dials, milling attachments, grinding attachments, gear cutting attachments, turret attachments, and taper attachments.

Lathe Centers

The two centers commonly referred to as live center (head stock center) and dead center (tailstock center) are where jobs are typically held on lathes. They are utilized to hold and support the cylindrical jobs, and they are built of highly hard materials to resist deflection and wear.

Carriers or Driving Dog and Catch Plates

When a job is split between two centres, these are employed to drive it. A setscrew secures carriers or driving dogs to the job's end. The employment of a lathe dog for holding and supporting the job. Screws or bolts are used to attach catch plates to the headstock spindle's nose. The slot made available in each of them is designed to accommodate a protruding pin from the carrier or catch plate.Figure 6 shows lathe dog. This gives the lathe spindle and work a positive drive.

Chucks

One of the most crucial tools for holding and rotating a work in a lathe is the chuck. It is essentially fastened to the lathe's headstock spindle. The exterior threads on the spindle nose of the chuck attach to its internal threads. Short, cylindrical, hollow objects or those with irregular shapes that can't be mounted between centres can be held firmly and readily in a chuck. Jobs that cannot be conveniently mounted between centres because to their short length, big diameter, or uneven shape are swiftly and rigidly secured in a chuck.

Lathe chucks come in a variety of designs, such as-

(1) Three-jaw or universal

(2) Four-jaw independent

(3) Magnetic chuck

(4) Collet chuck

(5) Air or hydraulic chuck powered chuck

(6) Combination chuck

(7) Drill chuck

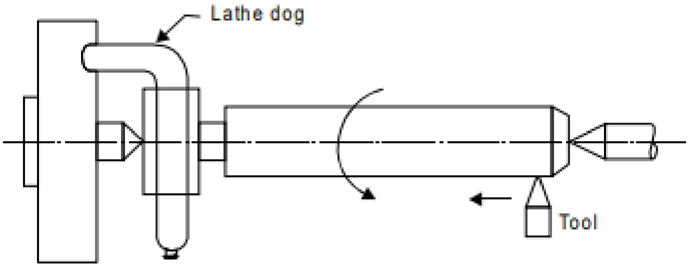

Figure 6: Shows lathe dog (wordpress.com).

Face Plates

Jobs that cannot be conveniently held between centres or by chucks are held using face plates. A face plate has radial, plain, and T slots for clamps and bolts to keep tasks or workpieces in place. A round disc that has been threaded to suit the lathe spindle's nose makes up face plates. They have strong, robust ribs on the back and are powerfully built. Because they have slots carved into them, the jobs on the face plate are held in place by nuts, bolts, clamps, and angles. They have been ground and machined precisely.

Angle Plates

A cast iron plate known as an angle plate has two faces that have been precisely machined to be at right angles to one another. On both faces, there are holes and slots so that it can be clamped on a faceplate and hold the project or workpiece on the other face using clamps and bolts. When it is necessary to maintain the horizontality of the job's holding surface, the plates are utilized in conjunction with a face plate.

Mandrels

A mandrel is a tool used to retain and rotate a hollow object that has already been bored or drilled. The mandrel, which is positioned between two centres, turns with the work.It is driven by friction to rotate by the catch plate and the lathe dog. Various types of mandrels are used according on the requirements. It is a steel shaft or bar that has been hardened, tempered, and given 60-degree centres so that it can be placed between centres. A part is held and located by it using its centre hole. The mandrel is never put in a chuck to turn the job; it is always rotated using a lathe dog. In contrast to an arbour, a mandrel is a tool for holding jobs rather than holding cutting tools. By suspending it on a mandrel between centres, a bush can be faced and turned. Typically, it is utilised to machine a hollow job's full length.

Rests

A rest is a lathe tool that supports a long, thin job while it is being turned between centers or by a chuck at a specific intermediate point to prevent the job from bending under the weight of itself and from vibrating as a result of the cutting force acting on it. The steady or center rest and the follower rest are the two types of rests that are frequently used in engine lathes to sustain a lengthy task.Figure 7 shows specifications of lathe.

Specification of Lathe

The following methods are typically used to determine a lathe's size:

(a) (a)Swing or the largest diameter that can be rotated over the bed ways

(b) The longest work that can be held between the centers of the head stock and the tail stock

(c) The length of the bed, which may also include the length of the head stock;

(d) The largest diameter of the bar that can fit through the spindle or collect chuck of the capstan lathe.

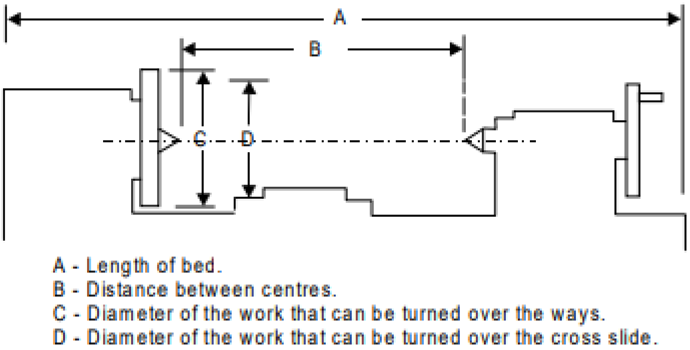

Figure 7: Shows specifications of lathe (wordpress.com).

Any of the following techniques may be used to support and drive the job of carrying out the various machining processes in a lathe.

1. Chuck holds and drives the job, and the other end is supported by the center of the tail stock.
2. The job is driven by carriers and catch plates and is held between centers.
3. The job is supported on a mandrel that is driven by carriers and catch plates and supported between centers.
4. A chuck, a faceplate, or an angle plate holds and drives the job.

The two types of job holding methods mentioned above are job held between centers and job held by a chuck or other device. Figure 8 show the various significant lathe operations. Three basic categories can be used to understand the actions taken in a lathe.

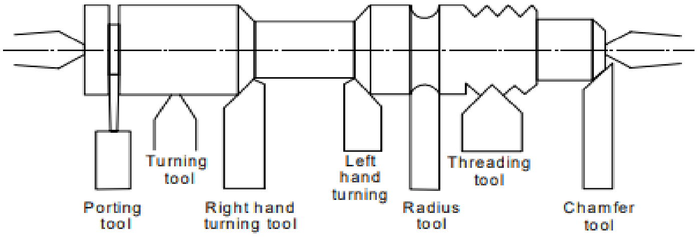

Figure 8: Shows lathe operation (wordpress.com)

Tapers and Taper Turning

A taper is described as a consistent increase or decrease in a work's diameter along its length. Taper turning on a lathe machine refers to creating a conical surface by gradually decreasing the diameter of a cylindrical task. The British System taper or taper per inch, depending on the measurement.

$(D - d)/l$ = Taper per inch

Where D is the diameter of the big end of the cylinder, d is the diameter of the small end, and l is the length of the taper, all of which are represented in inches. The diameters are indicated in inches when the taper is expressed in taper per foot, while the length of the taper is expressed in feet. In a lathe, a taper is typically turned by feeding the tool at an angle to the workpieces rotational axis. The half taper angle should be the angle created by the tool's path with the workpieces axis.

A taper can be turned by anyone of the following methods:

1. By swiveling the compound rest
2. By setting over the tailstock centre
3. By a broad nose form tool
4. By a taper turning attachment
5. By combining longitudinal and cross feed in a special lathe
6. By using numerical control lathe.

Taper Turning by Swivelling the Compound Rest

By rotating the workpiece on the lathe axis and feeding the tool at an angle to the workpieces axis of rotation, this technique applies the turning taper concept. The tool is positioned on a compound rest that is joined to a graduated-angle circular base. As shown in Figure 9 the compound rest can be readily rotated or swivelled and secured at any desired angle. Rotation of the compound slide screw will cause the tool to be fed at that angle and produce a corresponding taper after the compound rest is set to the correct half taper angle. Due to the limited movement of the cross-slide, this approach can only turn a short but steep taper. To enable turning a steep taper, the compound rest can be swivelled at 45° on either side of the lathe axis. In this technique, the single point cutting tool's motion is entirely controlled by the user's hand. As a result, it offers a subpar surface finish and low manufacturing capacity. If the half taper angle is already known, the compound rest can be positioned or fixed by rotating the rest at that angle. The half taper angle can be computed if the small end and big end diameters and the taper length are known. Figure 10 provides the entire configuration for creating a taper by swollen the compound rest[10]–[12].

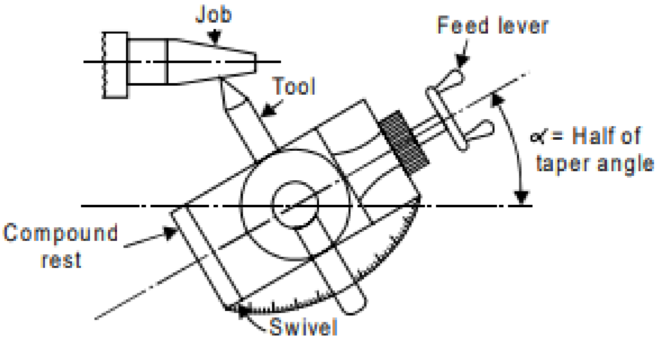

Figure 9: Shows taper turning by swivelling compound test (wordpress.com)

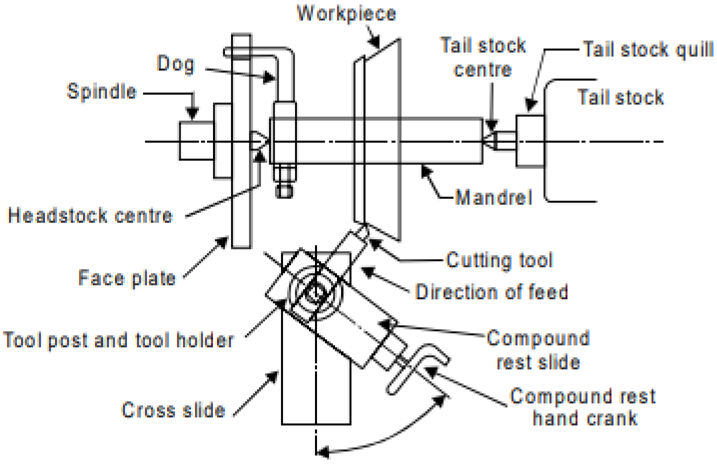

Fig. 10 shows swivelling compound rest set-up (wordpress.com).

CONCLUSION

The conclusion emphasizes the need of knowing the various varieties of lathe machines and their unique applications. Each type of lathe, from simple manual lathes to sophisticated computer numerical control (CNC) lathes, has distinctive capabilities that are tailored to a variety of manufacturing needs and also highlights the critical elements and tasks performed by the spindle, chuck, tool post, and feed mechanism during the lathe machining process. To maximize the output and performance of the lathe machine, operators must have a thorough understanding of these components.

REFERENCES

[1] A. Suryanto, D. A. Kusumawati, And I. M. H. Sanhoury, "Development Of Augmented Reality Technology Based Learning Media Of Lathe Machines," *J. Pendidik. Teknol. Dan Kejuru.*, 2018, Doi: 10.21831/Jptk.V24i1.18245.

[2] Z. Sialvi, . "Lathe Machine And It's Mechanism 1.1. Introdunction," *Mech. Mech. Eng.*, 2020.

[3] A. Kumar, "Lathe Machine: Definition, Introduction, Parts, Types, Operations, And Specifications," *Learn Mech.*, 2021.

[4] Z. N. Qureshi, Y. Mushtaq Raina, And A. Mohd, Syed Rufaie, "Strength Characteristics Analysis Of Concrete Reinforced With Lathe Machine Scrap," *Int. J. Eng. Res. Gen. Sci.*, 2016.

[5] F. Sultana *Et Al.*, "Effects Of Occupational Hazards On Pulmonary Health Among Lathe Machine Workers: A Cross-Sectional Study In Tangail, Bangladesh," *Int. J. Innov. Res. Med. Sci.*, 2021, Doi: 10.23958/Ijirms/Vol06-I11/1251.

[6] R. Sharma, R. Sharma, Y. B. Prabha, S. Rema Devi, P. Saxena, And T. Rajasanthosh Kumar, "Iot Monitoring Lathe Machine Performance," *Mater. Today Proc.*, 2021, Doi: 10.1016/J.Matpr.2021.07.300.

[7] D. Jang, H. Shin, S. Paul, J. Chang, And Y. Yun, "Design Of A High-Force Electromechanical Actuator For Electrically Driven Lathe Machine," *Ieee Trans. Ind. Electron.*, 2020, Doi: 10.1109/Tie.2019.2952780.

[8] Pankaj Barmase,“Optimization Of Turning Process Parameter For Lathe Machine By Using Taguchi Method.,” *Int. J. Eng. Sci. Res. Technol.*, 2021, Doi: 10.29121/Ijesrt.V10.I4.2021.7.

[9] R. Ramli, H. Yamamoto, And J. A. Qudeiri, “Tool Path Of Lathe Machine In Flexible Transfer Lines By Using Genetic Algorithms,” *Int. J. Prod. Econ.*, 2009, Doi: 10.1016/J.Ijpe.2008.04.016.

[10] G. Gupta And R. P. Mishra, “Comparative Analysis Of Traditional And Fuzzy Fmeca Approach For Criticality Analysis Of Conventional Lathe Machine,” *Int. J. Syst. Assur. Eng. Manag.*, 2020, Doi: 10.1007/S13198-019-00938-Y.

[11] J. M. Naje, “Wood Lathe Machine Analysis Using Taguchi Robust Method,” *Xinan Jiaotong Daxue Xuebao/Journal Southwest Jiaotong Univ.*, 2019, Doi: 10.35741/Issn.0258-2724.54.5.24.

[12] P. S. Koradiya, A. H. Kania, H. S. Vankhede, And P. A. Patel, “Conversion Of A Conventional Bench Lathe To Cnc Machine,” *Int. J. Eng. Tech. Res.*, 2018, Doi: 10.31873/Ijetr.8.12.94.

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A BRIEF INTRODUCTION ON TYPES OF MELTING FURNACES

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ABSTRACT

Melting furnaces are essential pieces of equipment used in industrial processes to heat-melt a variety of materials, including metals, alloys, and glass. The design, functionality, types, and uses of melting furnaces are highlighted in this abstract. The abstract also emphasizes how crucial temperature regulation, effective heat transfer, and safety issues are while operating a melting furnace. For the purpose of melting materials, melting furnaces are made to deliver a consistent and regulated heating environment. The precise requirements of the material being melted, such as the temperature range, heat capacity, and desired melting rate, determine the type of furnace that should be used. Crucible furnaces, induction furnaces, electric arc furnaces and reverberatory furnaces are typical melting furnace types, each with specific benefits and uses.

KEYWORDS: Coke, Cupola, Furnace, Iron,Metal.

INTRODUCTION

The metal to be cast must be molten or liquid before being poured into the mould. The primary mineral refining process is carried out in a furnace, although it is also primarily used to melt metal. Basic melting (of iron ore) operations are carried out in a blast furnace to produce pig iron, cast iron is produced in a cupola furnace, and steel is remelted in an electric arc furnace. For melting and remelting ferrous and nonferrous materials, various furnaces are used. The choosing of a furnace is determined by the considerations listed below. (i)Considering both the upfront and ongoing costs. Relative average repair and maintenance costs are (ii). (iii) The range of gasoline prices and availability in the specific area. (iv)Melting effectiveness, particularly melting speed. (v)The metal's composition and melting point.(vi)The level of quality assurance necessary for metal purification and refining, (vii) Operation noise and cleanliness. (viii) Personnel decisions or commercial pressure. The burning of fuel, electric arc, electric resistance, etc., all produce heat in a melting furnace. A furnace has a high temperature zone or region that is enclosed by a refractory wall structure that can sustain high temperatures and minimise heat loss to the surroundings because it is insulating. Different furnaces are used to refine and melt ferrous and nonferrous materials[1]–[3].

Furnaces for melting different materials

Grey cast iron is used in the following items:

1. Cupola, Air furnace (or Reverberatory Furnace), Rotary furnace and Electric Arc Furnace.

2. Steel

(a) Electric furnaces

(b) Open hearth furnace

3. Non-ferrous Metals

(a)Reverberatory furnaces (fuel fired) (Al, Cu)

(i)Stationary

(ii)Tilting

(b)Rotary furnaces

(i)Fuel fired

(ii)Electrically heated

(c)Induction furnaces (Cu, Al)

(i)Low frequency

(ii) High frequency.

(d)Electric Arc furnaces (Cu)

(e)Crucible furnaces (AI, Cu)

(i)Pit type

(ii)Tilting type

(iii)Non-tilting or bale-out type

(iv)Electric resistance type (Cu)

(f)Pot furnaces (fuel fired) (Mg and AI)

(i)Stationary

(ii)Tilting.

Blast Furnace

Different types of iron ores are transported to the blast furnace after mining, which is the first step in refining iron ores or mined ores and in the production of pig iron. In the fourteenth century, the blast furnace was created. It is a sizable steel shell that is lined with heat-resistant bricks and has a diameter of around 9 m. On top of a brick foundation, it is positioned. Hearth, Bosh, Stack, and Top are the four main components of a blast furnace from bottom to top. Molten metal and molten slag are kept in the hearth as a storage space. Iron ore, scrap, coke, limestone, and some steel scrap are layered in the blast furnace's charge, which is supplied from the top of the furnace.

As a collection of minerals containing iron, iron ore is present. Hematite, limonite, and magnetite are the names of the iron oxides that make up these mineral aggregates. They all help the smelting process along. A red ore called hematite has a 70% iron content. A hydrated oxide, limonite has a 60% iron content. About 72% of the iron in magnetite, a magnetic oxide, is iron. To make 1 tonne of pig iron, you need roughly 1.6 tonnes of iron ore, 0.65 tonnes of coke, 0.2 tonnes of lime stone, and about 0.05 tonnes of scrap steel and iron. About 4 tonnes of air are needed to burn this charge. The ore contains the impurities or other minerals. Silicon sulphur, phosphorus, manganese, calcium, titanium, aluminium, and magnesium are a few examples of these contaminants.

The purifying method utilised to create the steel will depend on the concentrations of silicon, phosphorus, and sulphur. Large ladles are used to collect the pig iron output from the furnace from the tap hole that is located at the bottom of the furnace. Ore melts and congregates in the hearth as the coke burns with the assistance of the air pumped into the furnace. The entire pile settles as the melting process continues, creating space for the top charges to be added. The limestone and impurities combine to form a slag as the material melts. The coke, which is manufactured from coal, is the second element that makes up the charge. Since it must support the charge, coke needs to be robust, dust-proof, and not too flammable. It provides the heat needed to melt the iron and reduce the ore. The iron absorbs impurities from the ore and carbon from the coke. The amount of carbon that the iron absorbs is greater than what is required to make steel. The carbon is incorporated into the pig iron needed to make steel. The qualities of the steel are controlled by this carbon during the succeeding procedures. Distillation is used to create coke from bituminous coal. Coke remains after the impurities are pushed away.

Cupola Furnace

Various cast irons are produced by melting scrap metal or pig iron in a cupola furnace. Additionally, it is utilized to make nodular and malleable cast iron. It comes in a nice range of sizes. The three important factors in cupola selection are melting capability, shell diameter with or without lining, and spark arrester.

Various zones of cupola furnace

Varying cupola zones experience varying numbers of chemical reactions. The following discusses the cupola's construction and several zones.

Well

The term "cupola" also refers to the area inside the cupola's cylindrical shell that lies between the bottom of the tuyeres and the sand bed. The molten metal is gathered in this area as it melts before being tapped out.

Combustion zone

The term "cupola" also refers to the area inside the cupola's cylindrical shell that lies between the bottom of the tuyeres and the sand bed. The molten metal is gathered in this area as it melts before being tapped out.

Reducing zone

Between the upper level of the combustion zone and the upper level of the coke bed is the reducing zone of the cupola, also referred to as the protecting zone. The temperature in this zone drops from the combustion zone temperature to roughly 1200°C at its top due to an endothermic reaction in which CO2 is converted to CO.

Melting zone

The melting zone of the cupola is the bottom layer of metal charge that is above the lower layer of coke bed. In this region, the metal charge begins to melt. It then trickles through the coke bed and collects in the well.

Preheating zone

The preheating zone extends from the melting zone's higher end to the charging door's bottom level. There are several alternate layers of coke bed, flux, and metal charge in this zone. Prior to sending the metal charge into the melting zone, the primary goal of this zone is to warm the charges from room temperature to around 1090°C. Due to the hot gases' upward migration in this area, preheating occurs there. The metal charge in solid form picks up some sulphur content in this zone during the preheating process[4].

Stack

Stack refers to the vacant space in the cupola that is located above the preheating zone. It offers the pathway for hot gases coming from the cupola boiler to reach the atmosphere.

Charging of Cupola Furnace

The metal and coke charges, which are laid out in alternating layers in the furnace, are adequately heated before the blower is turned on. The blower is turned on after the cover plates are properly positioned. The molten metal begins to trickle into the well and gather there. Each layer's coke charge height in the cupola varies, on average, by 10 to 15 cm. The quality of the charged metal and scarp, the composition of the coke, and the amount of ash present in the coke all play a role in how much flux is needed for the metal charge. For every metric tonne of metal used, 40 to 50 kg of limestone are typically used as flux. It is important to accurately calculate how much of this flux needs to be charged. The acid lining of the cupola is impacted by the excess flux.

Molten metal will be lost if thereis less flux than is necessary. The first charge of the molten metal is either used for rough castings or allowed to drain out. Controlling the proportions of the casting's various constituents during the stage of raw material requirements for melting is crucial for achieving the desired composition of the casting. It is also important because the melting process inside the cupola results in numerous losses and gains of various elements. These compositional losses and gains are noted for compensatory purposes.

Working of Cupola Furnace

To remove the old residue from an earlier charge, the furnace prop is first opened. Then, a rich refractory liner is used to repair the boiler. After positioning the prop, a small amount of coke is used to pick up fire, and then firewood is utilised to start the fire. Then, the small amount of oxygen is supplied for burning. Lime, coke, and metal are charged through the charging door on the coke bed and at the appropriate time when the blower is turned on. Air is pumped into the boiler by tuyers from the wind box. For the purpose of burning coke, pushed air rises upward through the stack furnaces. The coke not only provides fuel but also holds the charge till melting. The lime stone melts as the temperature rises and creates a flux that shields the metal from excessive oxidation. The coke ash is additionally fused and agglomerated by lime.

Melting starts, continues, and the bottom collects the molten metal. Before each skimming, molten metal can either be periodically tapped or the tap hole can be left open with metal flowing continuously. Slag is often emptied from the slag hole at the back of the furnace in cupolas. The bottom bar is abruptly pulled under the plates after the metal has completely melted, causing the bottom to drop. Figure 1 illustrates cupola furnaceSlag, unburned coke and molten metal are all expelled from the furnace. The melt charge is patched and made ready for the subsequent heat once it has cooled in the closing furnace[5]–[7].

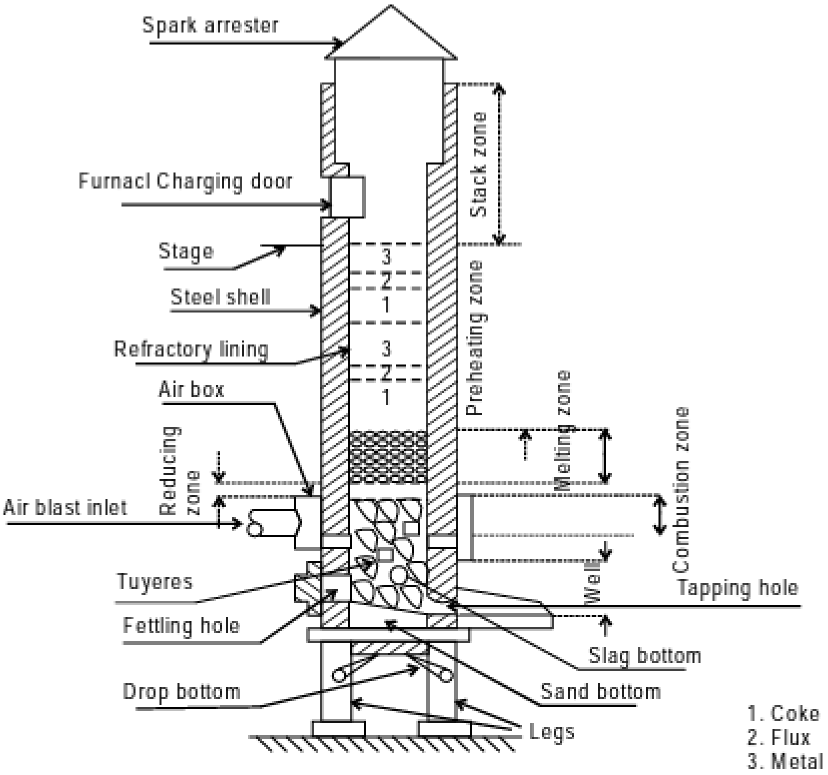

Figure 1: Illustrates Cupola furnace (wordpress.com).

Applications of cupola

Grey cast iron, nodular cast iron, malleable cast iron, and alloy cast iron are the types of cast iron that are most frequently produced using cupola melting techniques. Some copper-base alloys can be melted with it, and it can also be used in duplexing and triplexing processes to create steel, malleable cast iron, and ductile cast iron. Duplexing and triplexing processes can be used to prepare steel in a cupola. Two furnaces are utilized in duplexing melting activities, and three furnaces are used in triplexing operations.

Jamming of cupola furnace

A lot of care should be made to avoid cupola boiler jamming because it is a very prevalent issue. Due to the furnace operator's negligence, it happens regularly. The next sections cover possible temporary and permanent jamming of the cupola furnace.

Temporary Jamming of Cupola Furnace

The momentary choking of the tuyere mouths causes the cupola furnace to temporarily clog, which results in the temporary interruption of air supply in the tuyere zone. This is mostly produced by the tuyere apertures' low temperatures, which cause iron and slag to solidify around them. As a result, the air route becomes blocked, temporarily stopping the flow of air. Because the coke or fuel inside the boiler doesn't completely burn, the temperature inside the boiler quickly drops as a result. Therefore, it is necessary to often poke this solidified material through the tuyeres with a poking bar in order to prevent this momentary jamming. The cupola operator must always remain vigilant enough to prevent such solidification from continuing to melt for an extended amount of time in the furnace.

Permanent Jamming of Cupola Furnace

When the cupola boiler is permanently jammed, the air supply to the cupola is completely shut off as a result of the ongoing obstruction of the air path. This happens as a result of the slag overflowing into the wind chamber.

The level of the molten metal progressively rises as it melts and begins to accumulate in the furnace's well, while the lighter slag always floats on top of it. The amount of molten metal in the furnace will begin to rise in the well if it is not promptly tapped out owing to operator neglect, and eventually it will reach a point where it is close to the tuyere level. The slag will flow through the tuyere openings and into the wind belt if the cupola operator delays tapping even slightly longer.

Slag quickly solidifies in the wind belt and in the tubes because it comes into touch with the air at a low temperature, permanently clogging the air passageways in the furnace. Due to the aforementioned event, the cupola boiler ends up in such an unpleasant state. Therefore, the cupola furnace operator must constantly be attentive enough to tap the molten metal out of the well of the cupola furnace before the level of molten metal gets up to the tuyere level in order to avoid such an undesirable circumstance. As a result, the cupola furnace may continue to melt for longer.

Thermal Efficiency of Cupola Furnace

The ratio of heat actually used to melt and superheat the metal to heat that metal has evolved through various processes is known as the thermal efficiency of a cupola furnace. The total heat produced includes heat from the burning of coke, heat from the oxidation of iron, silicon, and manganese, as well as heat from the air blast. It is noted that during melting, roughly 48% of the heat that is evolved is lost.

Precautions for Safety of Cupola Furnace

The following safety measures must constantly be taken into consideration for proper cupola operation.Better quality refractory lining must be used to prepare or repair furnaces for the safety of the cupola because inferior lining will fuse and mix with molten metal to make slag at the high temperatures produced inside the furnace during melting. When starting the furnace, the furnace operator should always try to centre the metal charge. To ensure equal and thorough melting of the metal, he must make sure that the coke charge is evenly dispersed throughout and towards the firebrick lining. As the air moves through the tuyeres, the temperature around the holes will be relatively lower, which will cause the molten iron and slag to have a propensity to harden and block the apertures.

By repeatedly poking and removing these materials through the tuyeres with a poking rod, this should be avoided. Air supply volume needs to be correctly managed. A lack of air will always lead to incomplete burning of fuel, which is undesirable, while an excess much will always waste fuel while lowering the temperature within. The tap hole needs to be carefully sealed off using an appropriate filling method. Clay and coal dust combined in an equal amount make a highly effective plug for the tap hole.

When plugging the taphole, care must be given to press the plug downward in the hole to prevent splashes of molten metal from landing on the furnace operator's hands. Molten metal must always be removed from the cupola furnace well in advance, before its level gets too high. Any delay in tapping molten metal will cause the slag floating on the surface to start streaming into the wind belt through the tuyeres, obstructing the air channel and seriously complicating the clogging of the cupola furnace.

Open Hearth Furnace

Pig iron, steel scrap, and other materials are melted to create steel in an open-hearth furnace. In order to produce steel, American foundries frequently use this furnace. The heat from the burning of gaseous fuels above the charge, which is fed through a charging door, helps to raise its temperature to 1650°C. By burning adequately preheated air and gas, this heat is produced. These pre-heated gases and air are created by passing them through hot regenerators in the shape of an arc at a lower level. This has fire bricks in it that are positioned in a certain way to capture heat from exhaust fumes. In the boiler, hot firebrick checkers are used as a honeycomb through which fuel and air are conveyed. It warms the fuel and air to a temperature where they are prepared to burn when they enter the hearth.

The combustion byproducts travel through the checkers at the opposite end of the furnace simultaneously. Checkers are heated by hot gases. The process then turns around and utilizes the freshly heated checkers to heat the fuel and air. Regeneration is described as the process. After providing heat to the checkers, the combustion byproducts ascend through the stack. The charge is heated when coke is fired. Radiation from the chamber's low, heated roof contributes to some of the heat required.

To allow for the insertion of the charge, the charging platform is raised and bricked into place behind the furnace. Large ladles are filled from the front with the melt.The lining, the charge, and the control impurities injected during the melt after the melt has been tapped off into the ladle determine the chemical composition of the finished product. Impurities are greatly controlled by the lining.

Pig iron, limestone, and scrap iron make up the charge in a furnace with a magnetized liner. Limestone condenses to generate slag. Impurities are eliminated by the combination of this slag with airborne oxygen. While the carbon and silicon in the metal are being oxidized by the bubbling air, the sulphur and phosphorus in the metal are being reacted with by the slag. Iron ore is added to the melt if it contains too much carbon. The extra carbon is burned off by the iron oxide's oxygen. Pig iron is supplied if the carbon level is too low. Carbon gets replenished in this way.

As necessary, further alloying elements including Cr, Ni, Co, W, Mo, and V are added. After tapping, ferromanganese may be added to the crucible. Scrap iron and pig iron with a low phosphorus content should be the charge for an acid lining furnace. In order to keep the slag flowing, limestone is necessary. The fundamental lining burns phosphorus, silicon, and carbon as previously mentioned. The molten metals are allowed to spill over the sides of the crucible and into a slag pot, where it is tapped off.

One of the most crucial components employed in the reduction of the molten metal is oxygen. Some of the sources of oxygen include limestone, slag, rust, scale, and rust. Through the furnace's roof, oxygen lances are used to introduce oxygen into the furnace. The carbon reduction will increase by two when oxygen is added twice. As a result, the furnace produces more steel[8]–[10].

Pit Furnace

Small amounts of ferrous and non-ferrous metals are melted in pit furnaces, a type of furnace bath that is situated in the shape of a pit and used to make castings. Refractory is provided inside, and a chimney is provided on top. Figure 2 shows Pit furnaceCoke is typically used as fuel. It has a chimney at the top and an interior lining made of refractory material. Both natural and artificial draught can be used to improve the furnace's capacity for smooth operation.

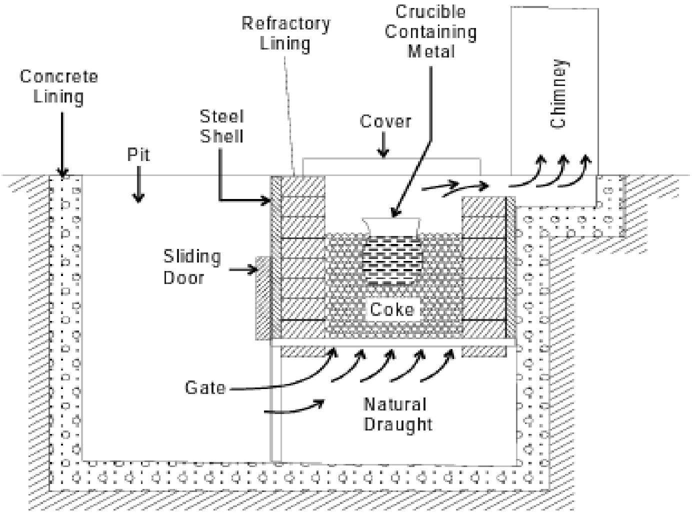

Figure 2: Shows Pit furnace (wordpress.com).

Coreless type induction furnace

High frequency induction boiler is another name for it. It consists of a copper coil with a refractory crucible positioned in the middle. This type of furnace's construction and operation are shown in Figure 3.

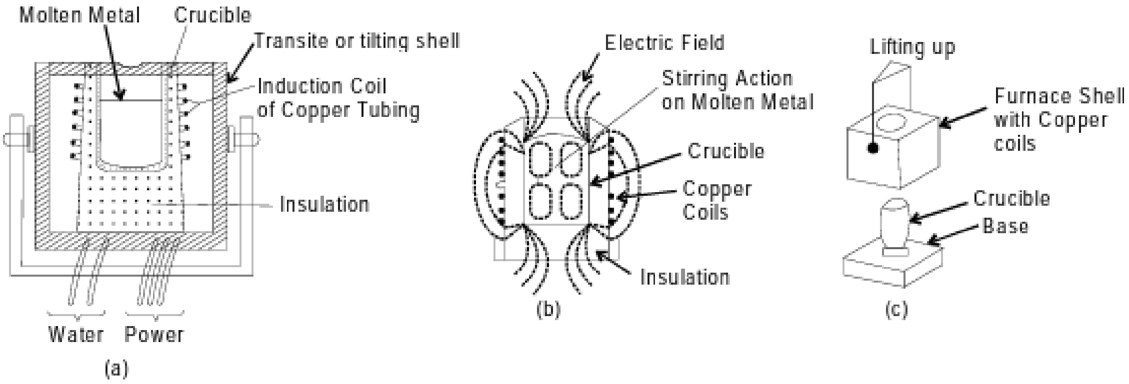

Figure 3: Illustrates Coreless type induction furnace (wordpress.com).

Air Furnace

Puddling or reverberatoryfurnace are other names for this furnace. It is employed to create wrought iron. The design of this kind of furnace is depicted in Figure 4.

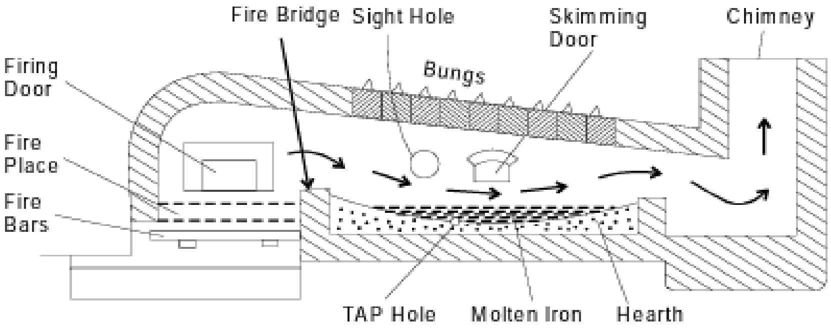

Figure 4: illustrates air furnace (wordpress.com).

CONCLUSION

In industrial processes where melting of materials is necessary, melting furnaces are crucial instruments. Based on unique needs, melting furnace designs, operations, and kinds vary, and effective heat transfer and temperature control are essential for top performance. A secure working environment is dependent on safety considerations. Melting furnaces are used for a variety of tasks, assisting in the manufacturing of goods from different industries. For melting processes to become more productive, use less energy, and be safer overall, constant improvements in furnace technology and control systems are necessary.

REFERENCES

[1] O. N. Popov and A. G. Gel’mut, “Prolonging the furnace campaign of glass-melting tank furnances,” *Glas. Ceram.*, 1979, doi: 10.1007/BF00698191.

[2] F. Shimizu, S. Fujino, and K. Morinaga, “Removal of impurity elements in EB-CHR melting process of metallic alloys,” *Nippon Kinzoku Gakkaishi/Journal Japan Inst. Met.*, 1998, doi: 10.2320/jinstmet1952.62.6_586.

[3] J. T. Brown, A. McMahon, C. L. Taylor, and D. Y. Yum, “The development and successful application of 100% oxygen-oil combustion for glass melters,” *J. Non. Cryst. Solids*, 1994, doi: 10.1016/0022-3093(94)90546-0.

[4] J. Schunicht, “Recovering of electronic scrap metals modern sorting processes in practical application,” 2007.

[5] K. Ishii, H. Murata, K. Kuwana, S. Mizuno, A. Morita, And T. Ida, “Combustion Simulation and Quick-freeze Observation of a Cupola-furnace Process Using a Bio-coke Fuel Based on Tea Scum,” *J. High Temp. Soc.*, 2009, doi: 10.7791/jhts.35.91.

[6] B. Fallentin and O. Kamstrup, “Simulation of past exposure in slag wool production,” *Ann. Occup. Hyg.*, 1993, doi: 10.1093/annhyg/37.4.419.

[7] V. I. Matyukhin, Y. G. Yaroshenko, A. V. Matyukhina, V. A. Dudko, and S. E. Punenkov, “Natural-gas heating of cupola furnaces for more energy-efficient iron production,” *Steel Transl.*, 2017, doi: 10.3103/S0967091217080113.

[8] V. I. Matyukhin, Y. G. Yaroshenko, A. V. Matyukhina, V. A. Dudko, and S. E. Punenkov, “The use of natural gas for heating of shaft furnaces of cupola type to

increase the technological processes efficiency of pig iron smelting," *Izv. Ferr. Metall.*, 2017, doi: 10.17073/0368-0797-2017-8-629-636.

[9] E. Siltanen, M. Koponen, A. Kokko, B. Engström, and J. Reponen, "Dust exposure in Finnish foundries," *Scand. J. Work. Environ. Heal.*, 1976, doi: 10.5271/sjweh.2838.

[10] T. Pettit and H. Linn, "A guide to safety in confined spaces," *DHHS Publ. No. 87-113*, 1987.

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CONCEPTS OF METAL CUTTING

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ABSTRACT

The removal of material from a metal workpiece in order to create desired forms, dimensions, and surface finishes is known as metal cutting. The main ideas, methods, and applications of metal cutting are highlighted in this abstract. Additionally, it covers how crucial tool choice, cutting parameters, and optimization are for successful metal cutting operations. The relevance of metal cutting as a critical procedure in contemporary manufacturing, enabling the fabrication of accurate and high-quality metal components, is summarized in the conclusion.

KEYWORDS: *Angle, Chips, Edge Tool, Machining, Metal Cutting.*

INTRODUCTION

The terms "conventional machining processes" and "metal cutting" are interchangeable. These procedures are frequently used in machine shops or tool rooms to use a wedge-shaped tool to shape, size, and finish a cylindrical or flat work on a rough block of job material. A layer of metal is removed from the workpiece in the shape of a chip thanks to restrictions on how the cutting tool can move in relation to it. Figure 1 displays typical metal cutting procedures. These machining operations are carried out using a variety of cutting tools (single or multi-point) on metal cutting machines, often known as machine tools. A machine tool is a metal cutting device that uses power to help control the necessary relative motion between the cutting tool and the project, which modifies the size and form of the job material. The mechanisms of the machine tool impart working motion to the workpiece and cutting tool during the metal cutting (machining) process so that the work and tool move relative to one another and machine the material of the workpiece in the form of shavings (or swarf) known as chips[1]–[3].

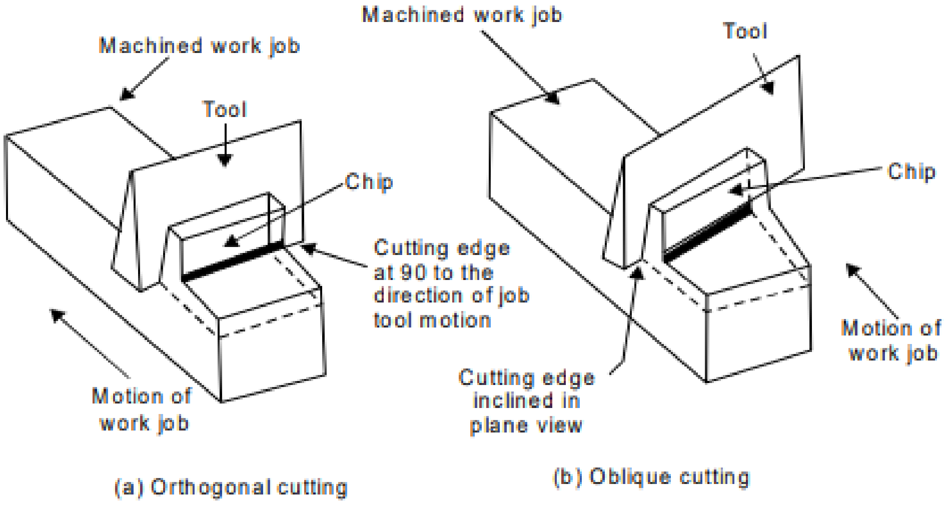


Figure 1: Shows orthogonal and oblique cutting (wordpress.com).

Cutting Tool

The main machining operation is carried out using cutting tools. They are made up of either single- or multi-point cutting instruments. It's a body with teeth or other cutting edges. A multi-point cutting tool, such as a milling cutter, milling cutter, drill, reamer, and broach, has numerous teeth or cutting edges on its periphery in contrast to a single point cutting tool, such as a lathe, shaper, planner, and boring tool, which has only one cutting edge.

Single Point Cutting Tools

Single point tools often come in two varieties: the solid variety. High speed steel or a cast alloy may be used to create the solid type single point tool. In tool holders, brazed tools, also known as tool bits are employed. The shank of the tipped type of tool is made of high-quality steel, and the tip is made of a material for cutting tools. Tip materials include cemented carbide or high-speed steel. Throwaway and long index-able insert tools are additional options. The term "Insert type tool throwaway" refers to the cutting tool insert that is held in the tool holder mechanically. The pre-made inserts are bought and put to use. The insert is discarded after all cutting edges have been utilized and is not sharpened again. Depending on the tasks they are employed for and the style of shank (straight or curved), these instruments can be further categorized. Tools could include those used for planning, turning, facing, drilling, splitting, slotting, etc. On pointed tools, many types of carbide tips are typically utilized. Tools with straight shanks generally cost less to produce than those with bent shanks. However, the bent shank type can be utilized for turning, facing, and chamfering operations as well as longitudinal or cross feed without the need for resetting. Boring tools often have a narrow cross section and are fairly lengthy. Figure 2 shown the a) Shows solid type of single point cutting tool, b) Shows tipped type single point cutting and c) Shows Index-able insert type single point cutting tool.

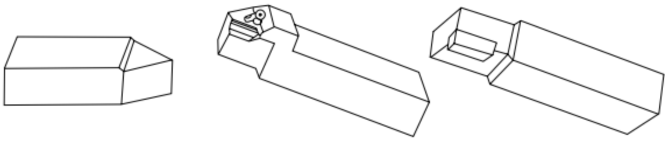


Figure 2: a) Shows solid type of single point cutting tool, b) Shows tipped type single point cutting and c) Shows Index-able insert type single point cutting tool.(wordpress.com).

The geometry of a single point cutting tool can be understood. The nose, the tool's rake face, the flank, the heel, and the shank are the main components of geometry. The nose has a conical form with various angles.Figure 3shows geometry of single point cutting tool. The angles are listed in the exact order that the American Society of Tool Manufacturer has determined they should be in.

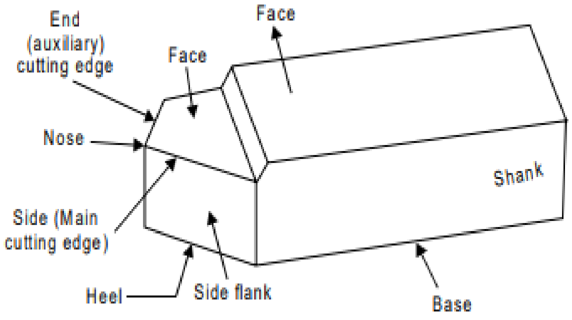


Figure 3: Shows geometry of single point cutting tool(wordpress.com)

Nomenclature of Single Point Tool

The elements of tool signature or nomenclature are discussed:

(i) Back rack angle

It is the angle, measured in a plane perpendicular to the side cutting edge of the tool, between the tool's face and a line parallel to its base. Back rake angle is negative if the slope face is downward towards the nose and positive if the slope face is upward towards the nose. This angle facilitates chip removal from the work piece.

(ii) Side rack angle

It describes the sideways inclination of a tool's face. The thickness of the tool behind the cutting edge is determined by the tool's angle. To prevent the work piece from rubbing against the tool's end flake, a space is left between the tool and the workpiece. It is the angle formed by the base's surface, the flank directly beneath the point, and the base's line of descent from the point.

(iii)End relief angle

It is described as the angle, measured at right angles to the end flank, between the area of the end flank directly beneath the cutting edge and a line perpendicular to the tool's base.
The term "end clearance angle" refers to the additional end clearance that is occasionally offered on a tool.
It is the subordinate angle that is immediately beneath the end relief angle. Because of the

angle, the tool may cut without rubbing against the workpiece. It is the subordinate angle that is immediately beneath the end relief angle.

(iv) Side relief angle

It is described as the angle, measured at right angles to the end flank, between the area of the end flank directly beneath the cutting edge and a line perpendicular to the tool's base. The term "end clearance angle" refers to the additional end clearance that is occasionally offered on a tool. It is the subordinate angle that is immediately beneath the end relief angle.

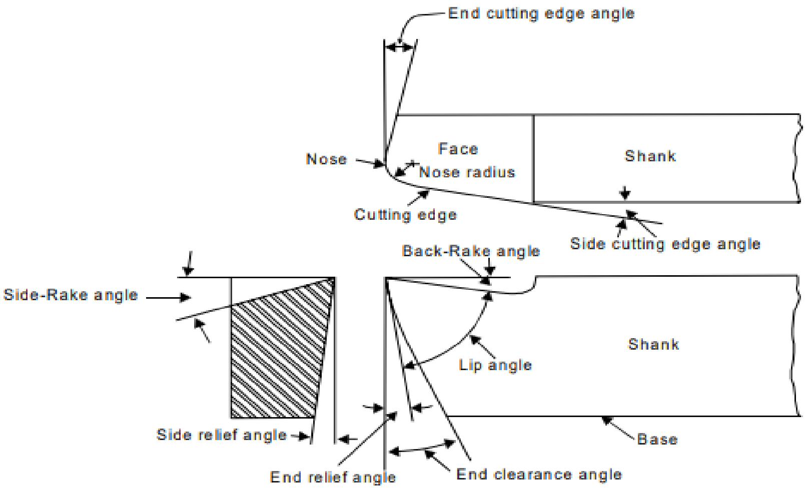


Figure 4: Shows elements of tool signature or nomenclature of single point cutting tool(wordpress.com).

The tool enters the material at an angle that prevents interference. It is the angle, measured at right angles to the side, between the area of the side flank directly below the side edge and a line perpendicular to the tool's base. It is a feature of the tool that provides relief between the surface of the work piece and its flank. Figure 4 shows elements of tool signature or nomenclature of single point cutting tool. The tool may occasionally have additional side clearance, often known as a side clearance angle. The secondary angle immediately following the side relief angle is this one [4]–[6].

(v) End cutting edge angle

It is the angle formed by the tool's cutting edge's end and a line perpendicular to the tool's shank. It allows space between the cutting edge of the tool and the workpiece.

(vi) Side cutting edge angle

It is the angle formed between the tool's straight cutting edge and the side of the shank. It also goes by the name lead angle. It causes the chip to turn away from the completed surface.

(vii) Nose radius

It is the connecting point between the side and end cutting edges. It has a tiny radius, which produces a smooth surface finish on the workpiece.

Mechanics of Metal Cutting

The work piece is firmly held in a vice, clamps, chuck, or collet from a machine tool. A wedge-shaped tool is pushed to travel in the direction depicted in the figure after being set to a specific depth of cut. A cutting tool with a fundamental wedge shape at the cutting edge is necessary for all conventional machining operations. The tool will shear or cut the metal provided that it is (i) harder than the metal, (ii) properly shaped so that its edge can effectively sever the metal, (iii) strong enough to withstand cutting pressures while being sharp enough to do so, and (iv) there is movement of the tool with respect to the material or vice versa to enable cutting action.

High speed steel or carbide tools are typically used for metal cutting. When cutting metal, the tool neither splits the metal like an axe cuts a log nor slides through it like a jack knife does through wood. The metal is really driven off the workpiece by being squeezed, being sheared off, and sliding down the cutting tool's face. The following explanation will help you understand how a cutting tool slices metal. All metals have a distinctive crystalline structure, also known as grain structure, when they are solid. The size of the grain or crystals can range from being very small to being quite coarse, depending on the type of metal and how it was heated.

Once more, the cutting tool moves through the work piece. The crystals in front of the tool face are subjected to strong forces. These crystals then apply identical pressure on crystals in front of them in the direction of the cutter's cut or force. The material at the sheared point is sheared by the tool's cutting edge as it moves forward, or it may be pulled loose by the action of the bending chip that is developing. Maximum stress is applied along the sheared line, also known as the shear plane, as the tool moves forward. This plane is roughly perpendicular to the tool's cutting face.

There is a shear zone on either side of the shear plane, and when the tool's force is greater than the material's strength there, the crystalline grain structure ruptures or slips, resulting in the formation of the metal chip. The chip rises up the tool face after becoming free of the workpiece material. Additionally, when a metal is sheared, the crystals elongate in a direction different from the shear direction. Figure 5 shows Metal Cutting OperationAfter leaving the shearing plane, the circles that depict the crystals in the uncut metal elongate into ellipses.

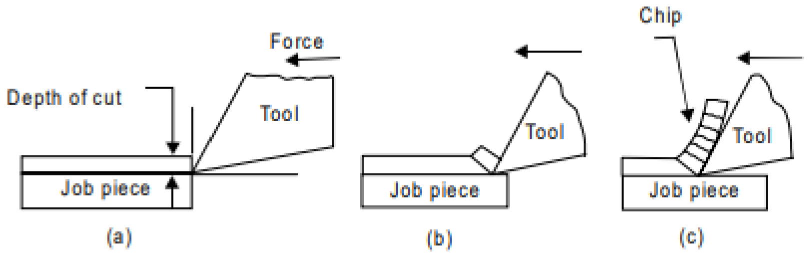


Figure 5: Shows Metal Cutting Operation (wordpress.com).

Types of Chips

In a machine shop, a metal cutting operation is completed. To give the workpiece the desired size and shape, chips are removed from the workpiece. The work material and cutting conditions mostly determine the kind of chipped edge that forms. There are four categories for the chips that result from metal cutting operations:

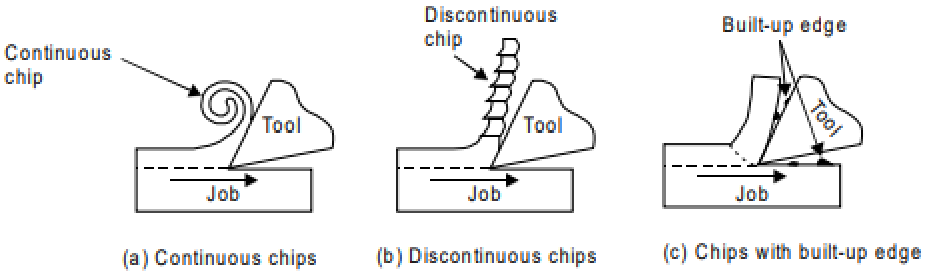
1. Chips that are segmented or continuous
2. Constant chips
3. Constant chips with a built-up edge.

4. Chips that aren't uniform

Continuous chips that are released during milling in a machine shop are seen in Figure 6 (a).

These chips are produced during the machining of ductile materials like copper and mild steel. In the absence of intentional breaking for handling convenience or safety, a continuous chip emerges from the cutting edge of a cutting instrument as a single unit. The machining process and the machine operators are at risk when very long chips form. It could become caught on the cutting tool or work piece and stop the cutting process. As a result, it becomes necessary to distort or fragment lengthy, continuous chips. Chip breakers are employed in the process. The chip breaker may be an inherent component of the tool or a separate gadget[7]–[9].

Small fragments of the chip are created in this type. When machining brittle materials like cast iron, brass, and bronze, these kinds of chips are produced. This kind of chips results in a rather good surface polish and lengthens tool life. A continuous chip with a built-up edge is shown in Figure 7 (c).



(a) Continuous chips (b) Discontinuous chips (c) Chips with built-up edge

Figure 6: Shows different types of chips(wordpress.com)

Temperature increases during cutting operations, and as the hot chip moves over the tool's face, alloying and welding may occur owing to high pressure. This causes the creation of weak bonds in the microstructure, and weakened particles may peel away. These particles become fused to the tool's cutting tip and create a fake cutting edge as a result of the intense heat and pressure that is produced. It is referred to as a built-up edge. When exceptionally hard alloys like titanium are machined, non-uniform chips form, and the yield strength of titanium decreases noticeably as the temperature rises[10], [11].Figure7 displays the three popular types of chips mentioned above.

CONCLUSION

In conclusion, metal cutting is an essential step in contemporary manufacturing that enables the production of accurate and superior metal components. It includes numerous methods and ideas that are crucial for accurate and successful material removal from metal workpieces.The choice of suitable cutting tools is one of the most important elements in efficient metal cutting. Depending on the workpiece material, required surface polish, and cutting speed, different cutting tools, such as high-speed steel (HSS) tools, carbide inserts, and diamond tools, are selected. Cutting effectiveness, tool life, and the quality of the machinable surface are significantly influenced by the shape, coatings, and materials of the tool.

REFERENCES

[1] M. Afrasiabi, H. Klippel, M. Roethlin, and K. Wegener, "An improved thermal model for SPH metal cutting simulations on GPU," *Appl. Math. Model.*, 2021, doi: 10.1016/j.apm.2021.08.010.

[2] I. Mukherjee and P. K. Ray, "A review of optimization techniques in metal cutting processes," *Comput. Ind. Eng.*, 2006, doi: 10.1016/j.cie.2005.10.001.

[3] J. Zhao, Z. Liu, B. Wang, J. Hu, and Y. Wan, "Tool coating effects on cutting temperature during metal cutting processes: Comprehensive review and future research directions," *Mechanical Systems and Signal Processing*. 2021. doi: 10.1016/j.ymssp.2020.107302.

[4] S. E. Mustafa, M. Ali, A. Iqbal, M. B. Naim Shaikh, and R. Hassan, "Formulation and analysis of cost-effective environment-friendly metal cutting nanofluids using zinc oxide on turning of AISI 52100 steel using MQL," *Eng. Res. Express*, 2021, doi: 10.1088/2631-8695/abd0e1.

[5] P. Yan, Y. Rong, and G. Wang, "The effect of cutting fluids applied in metal cutting process," *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*. 2016. doi: 10.1177/0954405415590993.

[6] K. Zhuang, C. Fu, J. Weng, and C. Hu, "Cutting edge microgeometries in metal cutting: a review," *International Journal of Advanced Manufacturing Technology*. 2021. doi: 10.1007/s00170-021-07558-6.

[7] M. Binder, F. Klocke, and B. Doebbeler, "Abrasive wear behavior under metal cutting conditions," *Wear*, 2017, doi: 10.1016/j.wear.2017.01.065.

[8] B. Wang *et al.*, "Advancements in material removal mechanism and surface integrity of high speed metal cutting: A review," *International Journal of Machine Tools and Manufacture*. 2021. doi: 10.1016/j.ijmachtools.2021.103744.

[9] J. M. Rodríguez, P. Jonsén, and A. Svoboda, "Simulation of metal cutting using the particle finite-element method and a physically based plasticity model," *Comput. Part. Mech.*, 2017, doi: 10.1007/s40571-016-0120-9.

[10] S. Sarath and P. S. Paul, "Application of smart fluid to control vibration in metal cutting: a review," *World Journal of Engineering*. 2020. doi: 10.1108/WJE-06-2020-0232.

[11] M. H. Lee, W. Yang, N. Chae, and S. Choi, "Performance assessment of HEPA filter against radioactive aerosols from metal cutting during nuclear decommissioning," *Nucl. Eng. Technol.*, 2020, doi: 10.1016/j.net.2019.10.017.

Special Issue

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PRINCIPLE AND METHODS OF MILLING PROCESS

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ABSTRACT

In the machining process known as milling, rotary cutters are used to remove material from a workpiece. Numerous industries, including manufacturing, the automobile and aerospace sectors, use it extensively. This abstract gives a quick rundown of milling, emphasizing its main features, uses, and benefits. The significance of milling as a flexible and effective method of material removal in contemporary production processes is discussed in the conclusion.

KEYWORDS: *Cutting Stroke, Feed, Motion, Shaper, Tool, Ram.*

INTRODUCTION

The function of a milling machine is to remove metal while feeding work against a spinning multipoint cutter. With the aid of numerous cutting edges, the milling cutter revolves at high speed while rapidly removing metal. On the arbor of a milling machine, one or more cutters may be installed concurrently. Because of this, milling machines are frequently used in manufacturing tasks. Flat surfaces, curved surfaces, surfaces of rotation, external and internal threads, and helical surfaces with different cross sections can all be machined with a milling machine. Figure 1 shows Job Surfaces Generated by Milling Machine**.** The components that a milling typically produces. Due to its faster output rate and accuracy, milling machines have even supplanted shapers and slotters in several applications.

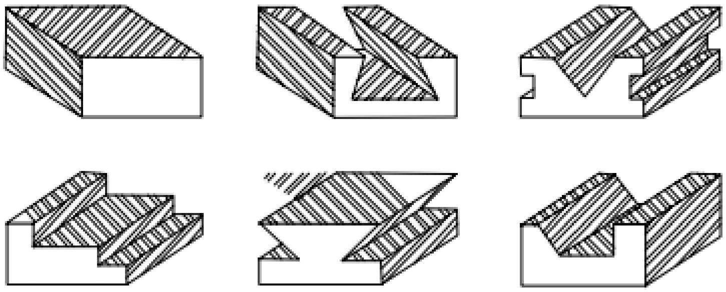

Figure 1: Shows Job Surfaces Generated by Milling Machine(wordpress.com).

Principle of Milling

A spinning cutter with numerous cutting blades is used in milling machines to cut metal. The workpiece is fed against the rotary cutter during the cutting process. Metal is removed from the workpiece as it moves up against the milling cutter's cutting edges in the form of trochoid-shaped chips. In one or more passes of the job, the machined surface is created. The workpiece is held in a vice, rotary table, three-jaw chuck, index head, between centers, custom fixture, or bolted to machine table while being machined. The type of material being machined determines the rotatory speed of the cutting tool and the feed rate of the workpiece[1]–[3].

Milling Methods

There are two distinct methods of milling classified as follows:

1. Up-milling or conventional milling
2. Down milling or climb milling

1. **Up-milling or Conventional Milling Procedure**

In the up-milling or conventional milling, as shown in Figure 2, the metal is removed in form of small chips by a cutter rotating against the direction of travel of the workpiece. In this type of milling, the chip thickness is minimum at the start of the cut and maximum at the end of cut. As a result the cutting force also varies from zero to the maximum value per tooth movement of the milling cutter. The major disadvantages of up-milling process are the tendency of cutting force to lift the work from the fixtures and poor surface finish obtained. But being a safer process, it is commonly used method of milling.

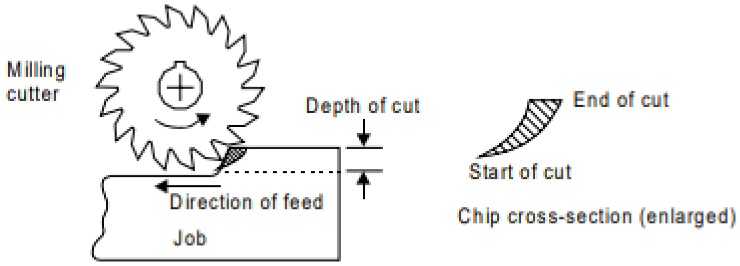

Figure 2: ShowsUp-milling or Conventional Milling Procedure(wordpress.com).

2. Down-Milling or Climb Milling

Additionally called climb milling. In this technique, the cutter rotates in the same direction as the workpieces feed to remove the metal. As a result, the teeth now cut downward rather than upward. The beginning of the cut has the thickest chips and the end has the thinnest. According to this procedure, there is less friction present, and as a result, less heat is produced on the cutter and workpieces contact surface. For more pieces per sharpening and a superior finish, climb milling is helpful for many different types of work. Saws cut lengthy, thin slots more successfully with climb milling than with regular milling. Another benefit of climb milling is that it can achieve slightly lower power usage because the table does not need to be driven up against the cutter.Figure 3 Principal of down-milling

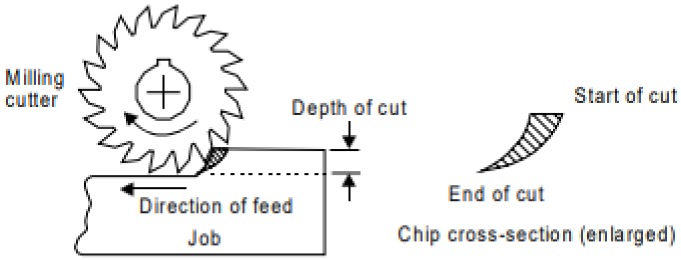

Figure 3: Shows Principal of down-milling (wordpress.com).

Types of Milling Cutters

Milling cutters are made in various forms to perform certain classes of work, and they may be classified as:

(1) Plain milling cutters

(2) Side milling cutters

(3) Face milling cutter

(4) Angle milling cutters

(5) End milling cutter,

(6) Fly cutter

(7) T-slot milling cutter

(8) Formed cutters

(9) Metal slitting saw

Milling cutters may simply have teeth on the ends or the periphery, or they may have teeth on both. Peripheral teeth can be helical, sometimes known as spiral teeth, or they can be straight or parallel to the cutter axis.

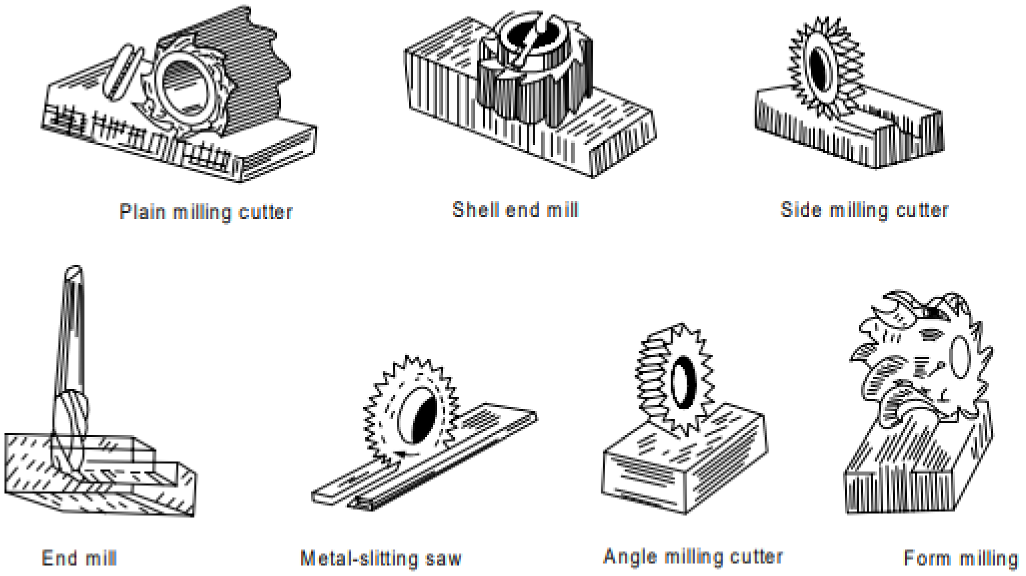

Figure 4: Shows types of milling cutters (wordpress.com).

DISCUSSION

Types of Milling Machines

A milling machine automatically feeds the work in the necessary direction while rotating the cutter located on the machine's arbour. The milling machine can be divided into numerous categories, but the size of the workpiece and the operations to be carried out ultimately determine which machine is selected. A number of types and sizes of milling machines are produced with the aforementioned function or necessity in mind. The different milling machine types include, in general design:

1. Column and knee type milling machine:

(a) Hand milling machine

(b) Horizontal milling machine

(c) Universal milling machine

(d) Vertical milling machine

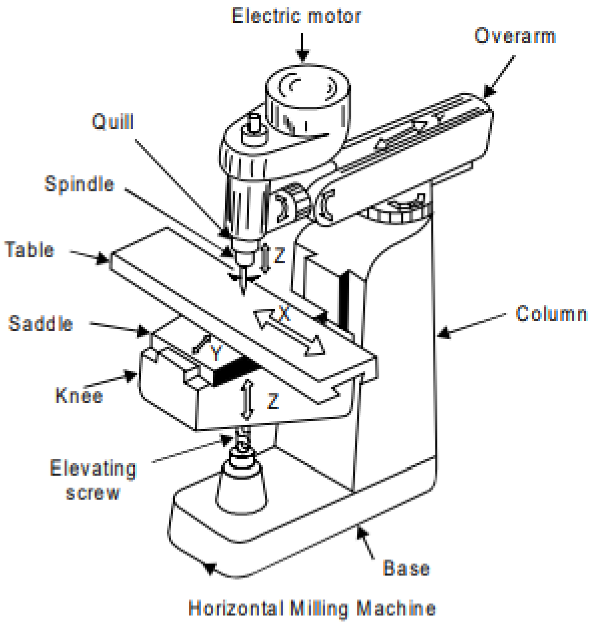

Figure 5: Shows horizontal column and knee type milling machine(wordpress.com).

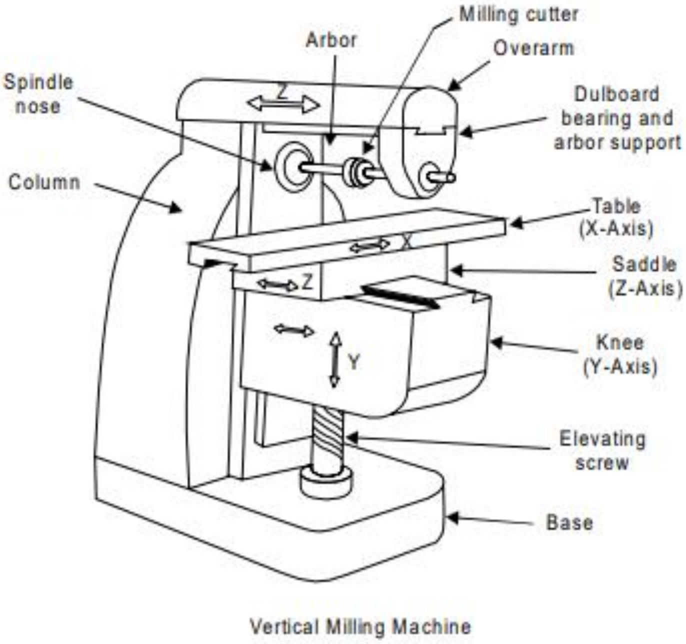

Figure 6: Shows vertical column and knee type milling machine(wordpress.com).

a) Planer milling machine

b) 3. Fixed-bed type milling machine

c) Simplex milling machine.

d) Duplex milling machine.

e) Triplex milling machine.

f) Machining center machines

g) Special types of milling machines

h) Rotary table milling machine.

i) Planetary milling machine.

j) Profiling machine.

k) Duplicating machine.

l) Pantograph milling machine.

m) Continuous milling machine.

n) Drum milling machine

o) Profiling and tracer controlled milling machine.

1. Column and Milling Type Knee Machine

A straightforward column and knee milling machine is depicted in Figure 7. It is the milling machine that is most frequently used for everyday shop work. The table of this kind of milling machine is fixed to the knee casting, which is fixed to the vertical slides of the main column. The column's knee is vertically movable so that the table can be raised to accommodate work at varied heights, up, and down. The numerous ways of powering the table, the varied movements of the table, and the various axes of rotation of the main spindle are used to categorise the column and knee type milling machines. The following crucial components are found in column and knee type milling machines:

1. Base
2. Column
3. Saddle
4. Table
5. Elevating screw
6. Knee
7. Knee elevating handle
8. Cross feed handle
9. Front brace
10. Arbour support
11. Arbour
12. Overhanging arm
13. Cutter
14. Cone pulley
15. Telescopic feed shaft.

16.

1. Base

It serves as a support member for all the other components, which rely on it. The column is carried by it at one end. Some machines have hollow bases that act as cutting fluid reservoirs[4]–[6].

2. Column

The primary supporting component installed vertically on the base is the column. It has a box-like shape, is strongly ribbed on the inside, and contains the entire spindle and table feed drive mechanism. The column's front vertical face is precisely machined and equipped with a dovetail guideway to support the knee.

3. Knee

The knee, which slides up and down on the vertical ways of the column face, is a rigid grey iron casting. The knee is supported and its height is adjustable using an elevating screw that is positioned on the base. The table's feed mechanism and other controls are housed in the knee.

4. Saddle

The saddle is positioned on top of the knee and moves along guideways that are precisely 90 degrees away from the column face. The table's guides are built into the saddle's top.

5. Table

The table moves longitudinally while resting on ways on the saddle. To move the table horizontally with either hand or power, a lead screw underneath the table must contact a nut on the saddle. The table of universal machines can also be turned horizontally. The table is fixed on a circular base for this purpose. T-slots are supplied for clamping the work and other fixtures to the table's accurately finished top.

6. Overhanging arm

It is attached to the top of the column and protrudes past the column face, acting as a bearing support for the arbor's other end.

7. Front brace

It is an additional support that is installed between the knee and the over-arm to give the arbor and the knee even more rigidity.

8. Spindle

It is located in the top of the column and transfers power to the arbor via belts, gears, and clutches after receiving it from the motor.

9. Arbor

On it, which resembles an extension of the machine's spindle, milling cutters are firmly fixed and rotated. For proper alignment with the machine spindles' taper holes at their noses, the arbors are manufactured with taper shanks. The arbor, spindle, and entire assembly are managed and locked using the draw bolt. Following are the parts of the arbor assembly.

2. Planer Type Milling Machine

It is a powerful milling device. It has a cross rail that can be raised or lowered holding the cutters, their heads, and their saddles, all of which are supported by stiff uprights, giving it the appearance of a planer. There could be two heads on the uprights and a number of independent spindles carrying cutters on the rail. The machine's use is restricted to production tasks only and is thought to have the highest capacity for removing metal.

3. Special Type Milling Machine

For certain uses, milling machines with unconventional designs have been designed. The ability to move the tool or the work in different directions and a spindle for spinning the cutting are standard characteristics.

Size of Milling Machine

The dimensions of the table's working surface and the table's maximum length for longitudinal, transverse, and vertical travel serve to define the size of the column and knee type milling machine. In addition to the aforementioned, further specifications will be needed for the number of spindle speeds, number of feeds, spindle nose taper, power available, and floor space needed, and machine net weight[7]–[9].

Depth of cut

The thickness of the material removed during a single pass of the piece under the cutter is referred to as the depth of cut in milling. In other words, it is the measurement of the angle between the workpieces original and final surfaces, and it is given in millimeters.

Indexing and Dividing Head

Indexing is the process of splitting a work's perimeter into as many equal pieces as necessary. Indexing is used to cut spur gears with uniform tooth spacing on the gear blank. As seen in Fig. indexing is carried out using a specialized attachment known as a division head or index head. Three different types of splitting heads exist.Figure 7 shows dividing head

(1) Plain or simple dividing head

(2) Universal dividing head

(3) Optical dividing head.

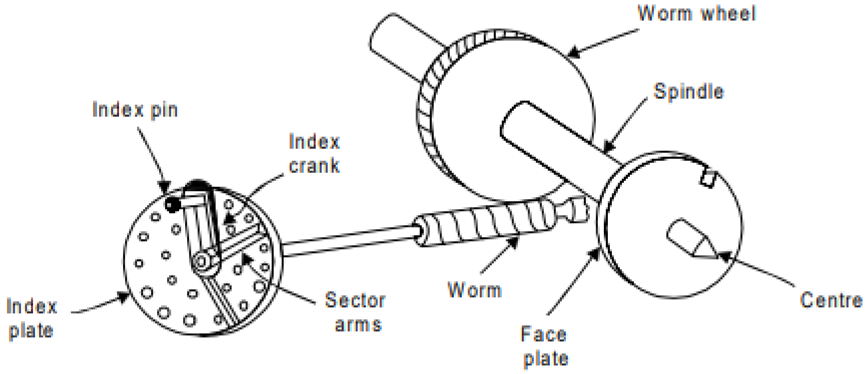

Figure 7: Shows dividing head(wordpress.com).

Plain or Simple Dividing Head

The basic splitting head consists of a base that is fastened to the machine table and a cylindrical spindle that is placed on a frame. The index crank and spindle rotate as a single unit since they are directly coupled to the spindle's tail end. The spindle, to which the index plate is attached, revolves together. By positioning the clamping lever pin into any of the evenly spaced holes or slots carved out on the outside edge of the index plate, the spindle may be turned through the necessary angle and then clamped. This kind of dividing head is utilized to handle numerous workpieces that just need a few divisions on the periphery[10], [11].

1. Swivelling block
2. Live centre
3. Index crank
4. Index plate

Operations performed on Milling Machine

A milling cutter, unlike a lathe, begins with a sliding action between the cutter and the job instead of providing a continuous cut. The chip is subsequently removed with a crushing motion and a cutting action that follow. A milling machine can carry out a wide range of operations, but we'll focus on a few of the more typical ones for now which are:

1. Plain milling or Slab milling
2. Face milling
3. Side milling
4. Angular milling
5. Gang-milling
6. Form milling
7. End milling
8. Profile milling
9. Saw milling
10. T-slot milling
11. Keyway milling
12. Gear cutting milling
13. Helical milling
14. Flute milling

CONCLUSION

In conclusion, milling is an important machining technique that is essential to contemporary industry. It is ideal for a variety of applications thanks to its many benefits, including high precision, adaptability, and efficiency. Tight tolerance manufacturing of complicated shapes and components is possible when material can be removed from a workpiece precisely and accurately. The adaptability of milling is one of its main advantages. It can be modified to handle various materials, sizes, and geometries thanks to the variety of milling machine setups and cutting tools available. Milling offers manufacturers a versatile option for a range of machining requirements, from straightforward activities like flat surface milling to complicated procedures like 3D contouring.

REFERENCES

[1] B. Z. Balázs, N. Geier, M. Takács, and J. P. Davim, "A review on micro-milling: recent advances and future trends," *International Journal of Advanced Manufacturing Technology*. 2021. doi: 10.1007/s00170-020-06445-w.

[2] Z. Duan *et al.*, "Milling Force Model for Aviation Aluminum Alloy: Academic Insight and Perspective Analysis," *Chinese Journal of Mechanical Engineering (English Edition)*. 2021. doi: 10.1186/s10033-021-00536-9.

[3] Z. H. Loh, A. K. Samanta, and P. W. Sia Heng, "Overview of milling techniques for improving the solubility of poorly water-soluble drugs," *Asian Journal of Pharmaceutical Sciences*. 2014. doi: 10.1016/j.ajps.2014.12.006.

[4] C. Pereszlai and N. Geier, "Comparative analysis of wobble milling, helical milling and conventional drilling of CFRPs," *Int. J. Adv. Manuf. Technol.*, 2020, doi: 10.1007/s00170-019-04842-4.

[5] A. R. Bodie, A. C. Micciche, G. G. Atungulu, M. J. Rothrock, and S. C. Ricke, "Current Trends of Rice Milling Byproducts for Agricultural Applications and Alternative Food Production Systems," *Frontiers in Sustainable Food Systems*. 2019. doi: 10.3389/fsufs.2019.00047.

[6] H. Celikag, E. Ozturk, and N. D. Sims, "Can mode coupling chatter happen in milling?," *Int. J. Mach. Tools Manuf.*, 2021, doi: 10.1016/j.ijmachtools.2021.103738.

[7] T. Wu *et al.*, "Effect of milling methods on the properties of rice flour and gluten-free rice bread," *LWT*, 2019, doi: 10.1016/j.lwt.2019.03.050.

[8] R. Rumler *et al.*, "Chemical and physical characterization of sorghum milling fractions and sorghum whole meal flours obtained via stone or roller milling," *Foods*, 2021, doi: 10.3390/foods10040870.

[9] S. Firouzi, M. S. Allahyari, and S. Marzban, "Multi-criteria decision-making approach to choose the most appropriate rice milling system," *J. Saudi Soc. Agric. Sci.*, 2021, doi: 10.1016/j.jssas.2020.10.005.

[10] P. Dhankhar, "Rice Milling," *IOSR J. Eng.*, 2014, doi: 10.9790/3021-04543442.

[11] C. Yue, H. Gao, X. Liu, S. Y. Liang, And L. Wang, "A review of chatter vibration research in milling," *Chinese J. Aeronaut.*, 2019, doi: 10.1016/j.cja.2018.11.007.

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A BRIEF STUDY ON MOLD AND CORE MAKING

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ABSTRACT

Making molds and cores is a crucial procedure in the casting and foundry industries. For the precise and accurate shape and production of complicated metal parts, molds and cores are essential. In this abstract, the process of creating a mold and a core is described in general terms, emphasizing its importance to the industrial sector. In order to produce the final result, the mold-making process entails producing a hollow chamber in the correct shape, which is then filled with molten metal. Depending on the casting needs, different materials, such as sand, plaster, or metal, are utilized to create molds. The design and construction of molds, which can be both reusable and disposable, are essential for producing castings of a high caliber. On the other hand, core making entails creating a solid form that is then put within the mold to produce cavities or characteristics that cannot be achieved using just the mold. The final cast product benefits from the internal structures, precise features, and complicated shapes provided by the cores. They are necessary for casting components with hollow sections or intricate shapes and are often manufactured from sand or other refractory materials.

KEYWORDS: *Core, Grains, Molding, Sand, Silica.*

INTRODUCTION

Molds can be made from a suitable and workable material that has a high degree of refractoriness. Thus, the substance used to create the mold can be metallic or non-metallic. Cast iron, mild steel, and alloy steels are common materials in the metallic category. Molding sands, plaster of Paris, graphite, silicon carbide, and ceramics are included in the non-metallic category. However, due to a few of its intrinsic qualities, such as refractoriness, chemical and thermal stability at higher temperatures, high permeability and workability, together with strong strength, molding sand is the non-metallic molding material that is most frequently used. Additionally, it is very accessible and affordable. This chapter covers molding and core sand, its components, qualities, testing, and conditioning, how to make molds and cores, nomenclature for molds and cores, and various molding techniques[1]–[3].

Molding sand

The usual places to find molding sands are in ocean beds, rivers, lakes, granular rock formations, and deserts. The following are typical places to find molding sands in India:

1. Batala sand (Punjab)
2. Ganges sand (Uttar Pradesh)
3. Oyaria sand (Bihar)

4. Damodar and Barakar sands (Bengal- Bihar Border)
5. Londha sand (Bombay)
6. Gigatamannu sand (Andhra Pradesh) and
7. Avadi and Veeriyambakam sand (Madras)

Sands used for molding might be either natural or synthetic. Natural molding sands have an adequate amount of binder. In contrast, synthetic molding sands are made artificially utilising basic sand moldings ingredients (silica sand in 88-92%, binder 6-12%, water or moisture content 3-6%) and additional additions in proper weight proportions with flawless mixing and mulling in appropriate equipment.

Constituents of Molding Sand

Molding sand is primarily made up of silica sand, binder, moisture content, and additives.

Silica Sand

The primary component of molding sand is silica sand, which comes in the form of granular quarts and has sufficient refractoriness to give core and molding sand strength, stability, and permeability.

But as impurities, silica also contains trace amounts of iron oxide, alumina, lime stone, magnesia, soda, and potash. The presence of impurities like lime, magnesia, alkalis, etc. can be inferred from the chemical composition of silica sand. Lime, iron oxide, and alkali oxides in excess can all significantly lower the fusing point, which is not what you want. Small, medium, and big silica sand grains as well as angular, sub-angular, and rounded shapes can be used to specify the silica.

Effect of Grain Shape and Size of Silica Sand

The various characteristics of moulding and core sands are significantly influenced by the shape and size of the sand grains. The possibility of its application in various types of foundry practise is determined by the shape of the sand grains in the mould or core sand. The grains of foundry sand can be either spherical or angular in shape. While some sands include almost exclusively grains of a single shape, others contain a combination of different shapes. Foundry sands are divided into four different shapes: rounded, sub-angular, angular, and compound. Use of angular grains, which are formed from crushing hard sandstones, is discouraged because of their high surface area.

Because the specific surface area of an angular grain is bigger, molding sands made of those grains will require more binder and moisture. To get the requisite strength in the molding sand and core sand, a higher amount of binder is needed. Sand grains with a smooth surface are preferred for effective molding. The smooth surfaced grain has a higher sinter point and, while requiring a greater proportion of blind material, secures a combination of better permeability and flexibility. The best silica sand grain types for generating permeable molding sand are those with rounded shapes. In contrast to angular grain, these grains lead to a stronger bond strength. The thermal expandability of rounded silica sand grains is higher than that of angular silica grain sands, nevertheless[4]–[6].

Under the same circumstances, rounded silica sand produces substantially superior compact ability than sands with angular silica sand grains. This is related to the fact that rounded grain silica sand has the best degree of compact particle packing, whereas sand with angular grain sand has the worst. As the grains get more rounded, the green strength increases. On the other hand, silica sands with rounded sand grains have a higher degree of compact ability, and in addition, the contact surfaces between the individual grains are larger on rounded grains than on angular grains. As was already established, rounder grains promote compact ability. Therefore, rounded grains should have a higher permeability or porosity than angular grains in molding sand and core sand.

Thus, the qualities of molding sand are significantly influenced by the size of the round silica sand grain. The features of sub-angular sand grains are intermediate between those of angular and rounded sand grains. Compound grains are bonded together in a way that prevents sieving across a screen from separating them. They could be made up of sand grains that are spherical, sub- angular, or angular. Compound grains additionally call for increased binder and moisture content levels. Due to their propensity to melt at high temperatures, these grains are the least preferred in sand combinations. The compound grains are additionally glued together and do not separate when screened.

The distribution of grains and their sizes in molding sand strongly affects the sand's characteristics. The strength and other general properties of silica sand are significantly influenced by the size and shape of its grain. The compact ability of sand with a wide range of particle sizes is higher than that of sand with a limited distribution. A sand with a larger density will be produced by broadening the size distribution, which can be done simultaneously in both directions or to either the fine or coarse side of the distribution. Density is more affected by spreading to the coarse side than by spreading to the fine sand. Narrow grain distributions lower green strength while wide size distributions increase it. The permeability is significantly impacted by the particle size distribution. When compared to silica sand that contains grains of average fineness but of the same size, or limited dispersion, silica sand that contains finer and a wider variety of particle sizes will have poor permeability. The green density achieved by three ram strokes serves as an indicator of compact ability. The compact ability decreases with sand fineness and vice versa. This happens as a result of the fact that the specific surface rises as grain size falls.

In turn, this boosts the resistance to compacting by increasing the number of points of contact per unit of volume. The green intensity tends to peak at a grain size that is roughly equivalent to the medium grain size, though this trend is admittedly not very noticeable. Although the amount of bentonite doesn't change as the silica sand grain size decreases, the bentonite film does. The green strength is decreased as a result of the binder film's reduced thickness. However, the number of grains and, thus, the number of points of contact per unit of volume drastically drops with very coarse grains, reducing the green strength once again. In comparison to the finer silica sands, the sands with same particle size but larger void space have better permeability. If the size of the sand grains is uniform, this effect is stronger[7]–[9].

DISCUSSION

Binder

The binders can generally be either an organic or an inorganic substance. The inorganic group consists of items like Portland cement and clay sodium silicate. Clay is used as a binder in foundries and includes Kaolinite, Ball Clay, Fire Clay, Limonite, Fuller's Earth, and

Bentonite. Dextrin, molasses, cereal binders, linseed oil, and resins like phenol formaldehyde and urea formaldehyde are among the binders that fall under the organic category. For manufacturing cores, organic binders are typically employed. The bentonite kind of clay is the most often used of all the binders mentioned above. However, without the presence of moisture in the molding sand and core sand, this clay alone is unable to create bonds between sand grains.

Moisture

The molding sand has a moisture level that typically ranges from 2 to 8%. For the purpose of forming bonding, this quantity is added to the clay and silica sand mixture. This is the volume of water necessary to completely fill the pores between clay particles without separating them. The clay firmly retains this quantity of water, which is primarily responsible for giving the sand its strength. With more clay and moisture present, the influence of clay and water reduces permeability. With an increase in clay content, the compressive strength of the green material initially rises, but after a certain level, it begins to fall.

Other elements, referred to as additives, are used in addition to the basic constituents to improve the properties of molding sand.

Additives

To give the sand its unique properties, additives are typically added to the mixture of molding and core sand. The following are some commonly used additives for improving the characteristics of molding and core sands.

Coal Dust

The main purpose of adding coal dust is to create a decreasing environment during casting. Any oxygen at the poles is chemically bonded by this reducing environment, preventing it from oxidizing the metal. It is typically included in the molding sands when creating molds for castings made of malleable cast iron and grey iron.

Corn Flour

It is used to make the molding and core sand more collapsible and is a member of the starch family of carbohydrates. Heat in the mold totally volatilizes it, leaving room between the sand grains. This enables the free movement of sand grains, which ultimately results in the movement of the mold walls and reduces mold expansion and casting faults. The strength of the mold and core is greatly increased when corn sand is added to molding sand and core sand.

Dextrin

Dextrin is a member of the starch family of carbohydrates and functions similarly to maize flour. It improves the molds’ dry strength.

Sea Coal

In molding sand and core sand, sea coal a fine powdered bituminous coal takes up residence in the pores of the silica sand grains. The sand grains become constrained and are unable to move into a dense packing pattern because it transforms into coke when heated, which fills the pores and is unaffected by water. Thus, sea coal makes the mold and core surface smooth and clean by reducing the movement of the mold wall and the permeability in the mold and core sand.

Pitch

It is a soft coal that has been refined. Between 0.02% and 2% can be added to core sand and mold. It improves surface quality on mold surfaces, hot strength, and exactly mimics sea coal behavior.

Wood Flour

The comparatively long, thin fibers of this fibrous substance, which is combined with a granular substance like sand, keep the sand grains from coming into touch with one another. Between 0.05% and 2% can be added to core sand and mold. When heated, it volatilizes, giving the sand grains space to expand. Both expansion flaws and mold wall movement will increase as a result.Additionally, it makes both the mold and the core more collapsible.

Silica Flour

Pulverized silica is what it is known as, and it may be applied readily in amounts of up to 3% to improve the hot strength and finish on the surfaces of molds and cores. Additionally, it lessens the penetration of metal into the cores' and molds’ walls.

Kind of Molding Sand

Molding sands can also be divided into a variety of kinds, each of which is detailed below, depending on their application.

Green Sand

The term "green sand" also refers to tempered or natural sand, which is a freshly manufactured blend of silica sand and 18 to 30 percent clay with 6 to 8% moisture content. The binding for green sand is provided by clay and water. It is smooth, supple, airy, and porous. When pressed in the hand, green sand preserves its shape and the impression that it was given while being crushed. Green sand molds are those made with this sand since they don't need to be backed. This sand is inexpensive and readily available. It is frequently used to produce castings made of ferrous and non-ferrous metals.

Dry Sand

Dry sand is green sand that has been dried or baked in an appropriate oven following the creation of molds and cores. It is stronger, stiffer, and more thermally stable. It is most often appropriate for larger castings. Dry sand molds are those made with this sand.

Loam Sand

Sand and clay are combined with water to create loam, a thin plastic paste. Loam sand contains up to 50% clay by weight and 18% water. Molds made of loam are not shaped using patterns, but rather by sweeps. This is especially utilized for moldings loam for massive castings of grey iron.

Facing Sand

Sand used as the mold's face is freshly prepared. It touches molten metal when the mold is filled since it is right adjacent to the pattern's surface. This sand provides the initial coating all around the design and consequently for the mold surface. This sand must have a high strength refractoriness because it is exposed to the harshest environments. Without using recycled sand, it is built of clay and silica sand. To stop the metal from burning into the sand, various types of carbon are utilized. 25% fresh, properly prepared sand and 5% marine coal may be included in a face sand mixture for green sand used in cast iron. To create facings, they are occasionally combined with 6–15 times as much fine molding sand. A mold's face sand layer typically has a thickness of 22 to 28 mm. The face sand makes up between 10 and 15 percent of the total amount of molding sand.

Backing Sand

The whole volume of the molding flask is filled with backing sand, also known as floor sand, which supports the face sand. The most common material used for this is recycled molding sand. Because the ancient, frequently used molding sand is dark in color from the addition of coal dust and burning when it comes into touch with the molten metal, it is also referred to as "black sand."

System Sand

In automated foundries that use machine molding. The entirety of the molding flask is filled with so-called system sand. No facing sand is utilized in mechanical sand preparation and handling units. Water and unique chemicals are utilized to clean and reactivate the used sand. System sand is what is used in this. The strength, permeability, and refractoriness of the molding sand must be higher than those of backing sand because the entire mold is constructed of this system sand.

Parting Sand

To prevent the green sand from adhering to the pattern and to enable the sand on the separating surface to cope and drag apart without adhering, parting sand without a binder and moisture is employed. This silica sand is clear and free of clay, and it performs the same function as separating dust.

Core Sand

Sand that is used to create cores is sometimes referred to as oil sand. This is extremely rich silica sand combined with oil binders like core oil, which is made up of resin, light mineral oil, linseed oil, and other binders. For the sake of economy, big cores may also be made using pitch or flours and water.

Properties of Molding Sand

The following are the fundamental characteristics needed for molding sand and core sand.

Refractoriness

Refractoriness is the capacity of molding sand to endure high temperatures without degrading or fusing, enabling the production of sound casting. It is a very significant quality of molding sands. Refractoriness is only capable of being raised to a certain point.Poorly refractoriness molding sand may burn onto the casting surface, making it impossible to create a smooth casting surface. The amount of refractoriness is determined by the quartz content, SiO2, particle shape, and grain size. The refractoriness of the molding sand and core sand increases with both the SiO2 content and particle volumetric composition. The sinter point of the sand, as opposed to its melting point, is used to determine refractoriness.

Permeability

To allow any air, gases, or moisture that may be present or formed in the mold when the molten metal is poured into it to escape, the molding sand is also referred to as being porous. The casting must release all of the gas produced throughout the pouring and solidification processes in order to avoid defects. Grain size, grain shape, moisture level, and clay content in the molding sand are all factors that affect permeability. Sand ramming intensity directly influences how permeable the mold is. Utilizing vent rods to vent can further increase the permeability of mold.

Cohesiveness

The interaction and attraction of the sand grain particles within the molding sand is a characteristic of the material. As a result, molding and core sand's green, dry, and hot strength properties are improved by increasing the binding capacity of the molding sand.

Green strength

After adding water, the green sand needs to be strong and durable enough to allow for the creation and handling of the mould. Sand grains must be adhesive in order to do this, which means they must be able to stick to other objects. As a result, sand grains with a high adhesiveness will adhere to the sides of the moulding box. Additionally, the sand grains must possess the quality of cohesion, or the capacity to adhere to one another. By virtue of this characteristic, the pattern can be removed from the mould without damaging it, and the molten metal does not erode the mold's surface during flow. The amount, kind, and shape of clay as well as the moisture level all affect the green strength.

Dry strength

The moisture in the sand layer next to the hot metal evaporates as soon as it is poured into the mold, thus the dry sand layer needs to be strong enough to maintain its shape to prevent erosion of the mold wall during the flow of molten metal. Additionally, the dry strength prevents the metallic -static pressure of the liquid metal from causing the mold cavity to grow.

Flow ability

It is the sand's capacity to get compressed and exhibit fluid behavior. When slammed, it will flow uniformly to every area of the design and disperse the ramming pressure equally in all directions. Sand particles typically find it difficult to man oeuvre around corners or projections.

In general, flowability increases as green strength and grain size decrease. Additionally, clay concentration and moisture affect the flowability.

Adhesiveness

Molding sand has the ability to attach to or stick to foreign objects, such as the inner wall of a molding box.

Collapsibility

The sand mold must be collapsible when the molten metal in the mold solidifies in order for the metal to contract freely and naturally prevent ripping or breaking of the contracting metal.

Without this characteristic, the mold impedes the metal's ability to contract, which causes the casting to tear and shatter. In cores, this characteristic is greatly valued[10], [11].

Steps Involved in Making a Sand Mold

1. For a two-piece pattern, a molding box of the right size is first chosen in order to achieve the right wall thickness. Additionally, enough attention should be given so that the molding box can adjust the mold cavity, riser, and gating system (sprue, runner, gates, etc.).
2. Next, arrange the drag portion of the design on the bottom (ram-up) board with the separating surface down
3. Next, the facing sand is gently strewn all over the pattern to prevent it from sticking to the molding sand during the pattern's removal.
4. The drag is then filled with loose, prepared molding sand, which is then evenly rammed into the molding box all the way around the design. Ramming is then done after adding more molding sand, three to four times, repeat the process
5. To finish the drag, the excess sand is then removed using a strike-off bar to raise the molding sand to the same height as the molding flask.
6. The drag is then turned over, and the top is sprinkled with separating sand
7. The cope pattern is now positioned over the drag pattern, and alignment is accomplished using dowel pins.
8. The parting sand is then scattered all around the cope pattern after the cope (flask) has been placed over the rammed drag.
9. Sprue and riser pins are positioned vertically at appropriate locations with the assistance of molding sand. It will make it easier to create cavities that are the right size for pouring molten metal, etc.
10. If necessary, the gaggers in the cope are placed in appropriate areas. They shouldn't be placed too close to the pattern or mold cavity as this could cause the casting to cool and the cope to be uniformly filled with molding sand and ram.
11. Remove any extra sand from the cope's top.
12. Remove the sprue and riser pins, then use a vent wire to make vent holes in the cope.
13. Roll the cope on the bottom board while separating sand is spread across the surface of the cope.
14. The mold is rapped, the cope and drag patterns are removed, the mold is repaired as necessary, and dressing is applied.
15. The gate that connects the mold cavity's lower base to the sprue basin's lower base with the runner is then cut.
16. In the case of a dry sand mold, apply mold coating using a swab and bake the mold.
17. If necessary, place the cores in the mold and close it by inverting the cope over the drag.
18. The mold is then prepared for pouring when the coping is fastened with drag.

Core making

Core blowing, core ramming, and core drawing machines are primarily used to automate the process of creating cores. These machines are generally described as follows.

1. Core Blowing Process

The core sand is filled into the core box using compressed air according to the basic workings of a core blowing machine. To ensure that core sand particles deposit in the far corners of the core box, the compressed air is continuously moving at a high velocity. High kinetic energy cores are simultaneously shaped and rammed in the core box as they penetrate the core sand. Small bench blowers and large floor blowers are the two additional categories that can be used to categories the core blowing devices. Small bench blowers are very cost-effective for low-production core producing shops. The second war saw the initial introduction of bench blowers. Bench blowers gained a lot of popularity because to their excellent comparative productivity and straightforward design. The cartridge-oriented sand magazine is regarded as being a component of the main box machinery. One cartridge, however, can print numerous boxes that are almost the same size. Using hands, the cartridge is filled. The machine's right handle clamps the core box while its left handle blasts the core after the core box and cartridge are put inside it for blowing. The core sand magazine of a bench blower of the swing type swings from the blowing to the filling position. A bench blowing method with a fixed sand magazine is also available. It eliminates the need to move the magazine from the filling to the blowing position, saving time and effort. The floor model blowers have an advantage in that they are more focused on automation. These floor-standing blowers include automatic control and a stationary sand magazine. Sand channeling in the magazine is one of the main downsides of core blowing, but it can be avoided by stirring up the sand there.

2. Core drawing machines

When the core boxes have deep draws, the core drawing is favored. The core box is put on a core plate supported by the machine bed after being filled with sand. A vibrating vertical plate creates a rapping motion on the core box. The core can be removed from the core box with the help of this rapping motion. The core is pulled up after being rapped against the core box, leaving the core on the core plate. To create hollowness in the casting, the drew core is then further cooked before being used in the mold cavity.

CONCLUSION

Making a mold and a core is a crucial process in the casting and foundry industries. They make it possible to produce intricate metal pieces precisely and accurately. To produce castings of a high caliber, proper mold and core design, material choice, and manufacturing methods are essential. With the development of technology, production procedures for molds and cores have become more flexible, cost-effective, and efficient.

REFERENCES

[1] M. Kafara, M. Süchting, J. Kemnitzer, H. H. Westermann, and R. Steinhilper, “Comparative Life Cycle Assessment of Conventional and Additive Manufacturing in Mold Core Making for CFRP Production,” *Procedia Manuf.*, 2017, doi: 10.1016/j.promfg.2017.02.028.

[2] E. S. Almaghariz *et al.*, “Quantifying the role of part design complexity in using 3d sand printing for molds and cores,” *Int. J. Met.*, 2016, doi: 10.1007/s40962-016-0027-

5.

[3] C. M. Choe, S. H. Sok, W. S. Ri, W. C. Yang, U. H. Kim, and Y. G. Jong, “Manufacture of Plaster Core Mold for Large Oxygen Plant Components Using Fused Deposition Modeling (FDM),” *Int. J. Met.*, 2021, doi: 10.1007/s40962-020-00549-5.

[4] B. Yan, S. Liu, M. L. Chastain, S. Yang, and J. Chen, “A new FTIR method for estimating the firing temperature of ceramic bronze-casting moulds from early China,” *Sci. Rep.*, 2021, doi: 10.1038/s41598-021-82806-z.

[5] J. Tóth, J. T. Svidró, A. Diószegi, and D. Stevenson, “Heat absorption capacity and binder degradation characteristics of 3D printed cores investigated by inverse fourier thermal analysis,” *Int. J. Met.*, 2016, doi: 10.1007/s40962-016-0043-5.

[6] Y. Wang, R. long Yu, S. kui Yin, R. Tan, and Y. chun Lou, “Effect of gel time of 3D sand printing binder system on quality of sand mold/core,” *China Foundry*, 2021, doi: 10.1007/s41230-021-1085-8.

[7] M. Kafara, H. H. Westermann, E. Eisinger, and R. Steinhilper, “Development of a reference part for the evaluation of economic and ecological impact of future process chains in mold core making,” 2016. doi: 10.1115/DETC2016-59200.pdf.

[8] N. Prabhushankar and N. Balaji, “Various alternative sources for silica sand, binders and additives in sand casting and their properties - A review,” 2020. doi: 10.1088/1757-899X/993/1/012137.

[9] J. Wang, S. R. Sama, and G. Manogharan, “Re-Thinking Design Methodology for Castings: 3D Sand-Printing and Topology Optimization,” *Int. J. Met.*, 2019, doi: 10.1007/s40962-018-0229-0.

[10] K. Nyembwe, D. Oyombo, D. J. de Beer, and P. J. M. van Tonder, “Suitability of a South African silica sand for three-dimensional printing of foundry moulds and cores,” *South African J. Ind. Eng.*, 2016, doi: 10.7166/27-3-1662.

[11] C. Chelladurai, N. S. Mohan, D. Hariharashayee, S. Manikandan, and P. Sivaperumal, “Analyzing the casting defects in small scale casting industry,” 2020. doi: 10.1016/j.matpr.2020.05.382.

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A STUDY ON TYPES OF NON-FERROUS MATERIALS

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ABSTRACT

Because of their distinctive characteristics and wide range of uses, non-ferrous metals are essential to many different sectors. Non-ferrous metals include a wide variety of metallic components such copper, aluminum, zinc, lead, nickel, and titanium, in contrast to ferrous metals, which include iron as their main component. This abstract gives a general review of non-ferrous metals, emphasizing their characteristics, uses, and the rising significance of sustainable production and consumption methods. The outstanding qualities that non-ferrous metals possess make them suitable for a variety of applications. For instance, copper is crucial for electrical wiring, electronics, and power generation due to its superior electrical conductivity.

KEYWORDS: *Alloy, Bronze, Brass, Copper,Metal, Resistance, Strength.*

INTRODUCTION

In its pure condition the metal would be weak and mushy for most applications, but when combined with minor quantities of other alloys, it becomes strong and stiff. It may be blanked, shaped, drawn, turned, cast, forged and die cast. Its excellent electrical conductivity is a significant quality and is commonly utilized for overhead lines. It creates valuable alloys with iron, copper, zinc and other metals[1]–[3].

Aluminum

Pure aluminum has silvery hue and lusture. It is ductile, malleable and highly good conductor of heat and electricity. It has a very strong resistance to corrosion than the ordinary steel. Its specific gravity is 2.7 and melting point is 658°C. Its tensile strength ranges from 95 to 157 MN/m2. In comparison to its weight it is fairly sturdy.

Applications

It is generally employed in aviation and vehicle components where reduction of weight is a benefit. The strong resistance to corrosion and its non-toxicity make it a good metal for cooking utensils under usual settings. Aluminum metal of high purity has got strong reflecting power in the form of sheets and is, thus, commonly utilized for reflectors, mirrors and telescopes. It is used in creating furniture, doors and window components, rail tracks, trolley cars, automobile bodies and pistons, electrical cables, rivets, cooking utensils and collapsible tubes for pastes. Aluminum foil is used as silver paper for food wrapping etc. In a finely separated flake form, aluminum is exploited as a pigment in paint. It is an inexpensive and extremely useful non-ferrous metal used for constructing cooking appliances.

Aluminum alloys

The aluminum may be readily alloyed with other elements including copper, magnesium, zinc, manganese, silicon and nickel to enhance different qualities. The inclusion of modest quantities of alloying elements into other metals helps to turns the soft and weak metal into hard and strong metal, while yet preserving its low weight. Various aluminium alloys are

1. Duralumin,
2. Y-alloy,
3. Magnalium
4. Hindalium.

Durlamin

It is a significant wrought alloy. Its makeup has following chemical components.

Copper = 3.5-4.5%

Manganese = 0.4-0.7%

Magnesium = 0.4-0.7%

Aluminium = 94%

Properties

Duralumin may be extremely readily forged, casted and worked since it contains low melting point. It possesses strong tensile strength, similar with mild steel mixed with the characteristics lightness of Al. It nonetheless exhibits poor corrosion resistance and strong electrical conductivity. This alloy exhibits increased strength after heat treatment and age hardening. After working, if this alloy is age hardened for 3 or 4 days. This condition is known as age hardening.

It hardens spontaneously when exposed to ambient temperature. This alloy is soft enough for a working time after it has been quenched. It is low in weight as compared to its strength in contrast to other metals. It may be readily hot worked at a temperature of 500°C.However after forging and annealing, it may also be cold worked.

Applications

Duralumin is utilized in the wrought conditions for forging, stamping, bars, sheets, tubes, bolts, and rivets. Due to its better strength and less weight, this alloy is frequently utilized in automobile and aviation components. To strengthen the strength of duralumin sheet, a thin film of Al is rolled together with this sheet. Such combination sheets are commonly employed in air-craft industries. It is also applied in surgical and orthopedic work, non-magnetic work and measuring instrument parts building work[4]–[6].

Y-alloy

Y-Alloy is sometimes termed copper-aluminum alloy. The addition of copper to pure aluminum increases its strength and machinability. Its makeup has following chemical components.

Copper = 3.5-4.5%

Manganese = 1.2-1.7%

Nickel = 1.8-2.3%

Silicon, magnesium, iron = 0.6% each

Aluminum = 92.5%

Properties

The inclusion of copper in aluminum boosts its strength and machinability. Y-alloy can be readily cast and hot wrought. Like duralumin, this alloy is heat treated and age hardened. The age-hardening process of Y-alloy is carried out at room temperature for around five days.

Applications

Y-Alloy is generally used for cast applications, although it may also be utilized for forged components like duralumin. Since Y -alloy has superior strength than duralumin at high temperatures, therefore it is extensively utilized in aviation engines for cylinder heads, pistons, cylinder heads, crank cases of internal combustion engines die casting, pump rods etc.

DISCUSSION

Properties and applications of some important non-ferrous metals are listed below:

Magnalium

Magnalium is an alloy comprising aluminum, magnesium, copper, nickel and tin etc. It contains Al = 85 to 95%, Cu = 0 to 25%, Mg = 1 to 5%, Ni = 0 to 1.2%, Sn = 0 to 3%, Fe = 0 to 0.9%, Mn = 0 to 0.03%, Si = 0.2 to 0.6%.

It is created by melting the aluminium with 2-10% magnesium in a vacuum and then cooling it in a vacuum or under a pressure of 100 to 200 atmospheres.

Properties

Magnalium is low in weight and fragile. This alloy exhibits low castability and good machinability. It may be readily welded.

Applications

Due to its small weight and strong mechanical qualities, it is largely utilised for making aircraft and vehicle components.

Hindalium

A typical brand name for an aluminium alloy is hindalium. It is an alloy made of silicon, manganese, chromium, magnesium, aluminium, and more. Hindustan Aluminium Corporation Ltd., Renukoot (U.P.), produces it in India. Hindalium is frequently made as a rolled 16 gauge product. This alloy is used to make robust, hard, and inexpensive (relative to stainless steel) kitchenware. It also produces items with a great finish, superior scratch resistance, and little heat absorption**.**

Applications

Hindalium is mostly used to make anodized kitchenware. This alloy is used to make robust, hard, and inexpensive (relative to stainless steel) kitchenware. It also produces items with a great finish, superior scratch resistance, and little heat absorption**.**

Copper

One of the most often utilised non-ferrous metals in industry is copper. It is extracted from copper ores like azurite, melachite, copper glance, and copper pyrites. In the Indian states of Sikkim, Bihar, and Bharma, copper ores can be discovered.

Manufacture

To create an impure alloy, copper ore is first processed and then smelted in a reverberatory or small blast furnace. When blister copper is needed for the converter, sulphur and iron impurities are removed from the molten metal by blowing air through it. The technique of electrolysis is then used to purify copper even further.

Properties

Pure copper is a reddish-brown metal that is soft, malleable, and ductile. It effectively conducts electricity. Under normal circumstances, it doesn't corrode and can withstand the elements very well. Its melting point is 1084°C, and its tensile strength ranges between 300 and 470 MN/m2. It is one of the best heat conductors and has a high level of corrosion resistance. This non-ferrous metal is impervious to failure even when subjected to extreme bending and forging. There are casting issues. Copper becomes brittle when heated to red heat and chilled slowly, yet it becomes soft, malleable, and ductile when cooled quickly. Red heat can be used to weld it.

Applications

Electric cables and wires for electric machinery, motor winding, electric conducting appliances, and electroplating, among other uses, are typically made of copper. It is easily forgeable, castable, rollable, and wire-drawable. Tubes made of copper are frequently employed in the field of mechanical engineering for heat transfer purposes. It is utilised for kitchenware. Additionally, it is utilised in the manufacture of roofs, condensers, and boilers. When combined with tin, zinc, nickel, and aluminium, it is used to create valuable alloys. Brass, bronze, and gun metal alloys are created with the help of it. Copper can be alloyed with zinc, tin, and lead to create a variety of useful materials. Brass, a copper and zinc alloy, is used to make appliances, fixtures for the home, decorative items, and other things. Bronze is a copper and tin alloy with excellent corrosion resistance. Bearings and valves are made with it. High-speed machining can produce a good surface finish on bronze and brass. Important copper alloys include the following:

1. Brasses made of copper-zinc alloys
2. Bronzes made of copper-tin alloys

Brasses

Brasses are a common alloy of zinc and copper, which is their primary component. Additionally, they have trace levels of lead, tin, or aluminium. Brass is the most widely used copper-zinc alloy. Brasses come in a variety of varieties depending on the ratio of copper to zinc. A binary alloy's basic composition is 50% copper and 50% zinc. Brass's characteristics can be significantly altered by introducing small amounts of other elements. For instance, adding between 1 and 2 percent of lead improves brass's ability to be machined. Its strength is more than copper's, but its thermal and electrical conductivity are less. Brass alloys are particularly resistant to corroding from the air and are simple to solder. They are easily fabricatable by techniques like spinning and can also have metals like nickel and chromium electroplated on them. Below are some of the typical brass phases that are described[7]–[9].

Alpha Phase

Up to 36% of zinc will be present if the copper crystal structure is face centred cubic (FCC). Alpha brass is the name for this stable solution. Despite having better mechanical and corrosion-resistance qualities than copper, it has a lesser electrical conductivity.

Beta Phase

Beta brass will appear in the microstructure of the slowly cooled brass if the zinc content rises above 36%. It has a BCC, or body-centered cubic structure. At room temperature, this phase is challenging but not impossible.

Gamma Phase

Gamma phase appears in the structure of brass when the zinc level exceeds 45%. Due to the exceedingly fragile nature of this structure's alloy, it cannot be used for general engineering tasks. The numerous brass types are discussed as follows.

Red brass

The use of red brass as a heat conductor is significant. Cu is 85% Zn is 15%.

Properties

Excellent corrosion resistance and workability are characteristics of red brass. It has tensile strength between 27 and 31 kg/mm2. This brass has an elongation percentage of 42–48.

Applications

Heat exchanger tubes, condensers, radiator cores, plumbing pipes, sockets, hardware, etc. are mostly made of red brass.

Yellow Brass or Muntz Metal

The term "muntz metal" also applies to yellow brass. It has a Cu:60% Zn:40% content. great strength and great hot workability characteriseMuntz metal. Its approximate tensile strength is 38 Kg/mm2. This brass has a 45% elongation by percentage.

Applications

Rolling, extruding, and stamping can be used to hot work yellow brass or muntz metal. It is used to produce a variety of small parts for machines and electrical equipment, including fuses, bolts, rods, and tubes. Because of its superior corrosion resistance, this metal is used to make ship sheathing, valves, taps, condenser tubes, and pump part.

Cartridge Brass

It has 30% Zn and 70% Cu. It has a nice balance of ductility and strength. Its tensile strength ranges from 31 to 37 kg/mm2. This brass has an elongation percentage of 55–66%. Typically, it is transformed into rolled sheets. The metal alloy may be cold worked with ease utilizing techniques including pressing, deep drawing, and wire drawing.

Applications

It is used in the production of tubes, automotive radiator cores, metal fasteners, rivets, springs, and plumbing accessories.

Admiralty Brass

Cu is 71%, Zn is 29%, and Sn is 1%.

Properties

1. Admiralty brass has a high level of corrosion resistance.
2. It has a high level of resistance to seawater impingement attack.
3. Its approximate tensile strength is 30 kg/mm2.
4. It may include frigid work
5. It has good resistance to corrosion caused by sea water.
6. The percentage of admiralty brass that has elongated is 65%.

Applications

Condenser tubes in marine and other systems are made from admiralty brass. It is employed to create plates for use in shipbuilding. Additionally, it is used to create ship fittings, condenser plant parts, bolts, nuts, and washers.

Naval Brass

Frequently, nautical brass is utilized to create marine parts. Cu is 59%, Zn is 40%, and Sn is 1%.

Properties

Muntz metal and naval brass have comparable physical characteristics. Navel brass has greatly enhanced corrosion resistance to sea water due to the substitution of 1% tin for 1% zinc in Muntz metal. The approximate tensile strength of navel brass is 38 kg/mm2, and its percentage elongation is 47%.

Applications

Navel brass is frequently used to make welding rods, piston rods, propeller shafts, and castings for nautical hardware.

Manganese Brass

Manganese bronze is another name for manganese brass. It has a Cu:60% Zn:38% content. Fe:1.0% Mn:0.5% Sn:0.5%.

Properties

There is enough hardness and strong corrosion resistance in manganese brass. It reduces the oxides of other metals quite quickly.

Applications

Hydraulic rams, valves, cylinders, tubes, pump rods, propellers, bolts, nuts, etc. are all made of manganese brass.

Iron Brass or Delta Metal

Iron brass or delta brass is composed of 60% Cu, 37% Zn, and 3% Fe. Iron brass, often known as delta metal, is a strong metal that resists corrosion well. It is simple to cast.

Applications

Mild steel must have some iron, brass, or another metal added to it in order to withstand corrosion.

Gliding Brass

Gilding brass is a fairly affordable metal used to create jewellery and other ornamental and decorative items. Typically, Cu is 85% Zn is 15%.

Applications

This metal is frequently used for jewellery, decorative, and ornamental work due to its excellent appearance.

Free Cutting Brass

The composition of free-cutting brass is Cu=57.5% Zn=40% Pb=2.5%. Brass that is available for free cutting is very machinable but it cannot be bent.

Applications

To create cast, forged, or stamped blanks for subsequent machining, such as high speed turning and screwing, free cutting brass is employed.

Lead Brass

Cloak brass, sometimes known as lead brass, has a composition of Cu = 65% Zn = 34% Pb = 1%.

Applications

Small gears and pinions for clockwork are made of lead brass, also known as cloak brass.

Bronzes

A typical copper and tin alloy is called bronze. Bronze is a common word for the copper and tin alloys. These alloys come in a variety of compositions, ranging from 5 to 25% tin and 75 to 95% copper.

Properties of Bronzes

Brasses cannot compare to the strength and corrosion resistance of bronze. It can be easily shaped or rolled into wire, rods, and sheets due to its relative hardness, resistance to surface wear, and ease of shaping. It has bearing or antifriction characteristics. Brass is less expensive than bronze. When tin content is around 20%, bronze's tensile strength reaches its maximum rate of increase. But if the tin concentration percentage rises above this level, the tensile strength falls off extremely quickly. When bronze contains 5% or less tin, it is at its most ductile. The ductility steadily declines as the tin content rises by about 5%, almost disappearing at around 20% tin. While the zinc content of bronze increases the molten metal's fluidity, strength, and ductility.Some of the common types of bronzes are discussed below:

Phosphor Bronze

Phosphor bronze is created when very minute amounts of phosphorus are present in bronze. The following describes a typical phosphor bronze's chemical make-up. Cu=89 to 94% Sn=6 to 10% P=0.1 to 0.3%.

Properties

With a rise in phosphorus in bronze, the tensile strength, ductility, elasticity, soundness of castings, high wearing quality, and resistance to fatigue all increase. Because of its excellent resistance to corrosion, particularly in seawater, this material is frequently used for propeller blades. When properly composed, phosphor bronze is simple to cast, forge, draw, and cold roll.

Applications

Bolts, electric contact springs, bearings, bushes, gears, ship sheathing, valve components, propeller blades, worm wheels, gears, nuts for machine lead screws, pump components, linings, and many more items are made of phosphorus bronze. Additionally, it can be used to create corrosion-resistant mine cables and springs.

Silicon Bronze

Cu is 96% Si is 3% Mn or Zn is 1% in silicon bronze. In addition to having superior strength, silicon bronze has good overall corrosion resistance to copper. It can be heated or cooled and cast, rolled, stamped, forged, and pressed in addition to being weldable using all the standard techniques.

Applications

Boilers, tanks, stoves, and other structures requiring great strength and excellent corrosion resistance are frequently made using silicon bronze. Additionally, it is used to make pumps, tubing, screws, and other items.

Beryllium Bronze

Cu=97.5% Br=2.5% makes up the copper base alloy known as "beryllium bronze." The tensile strength of beryllium bronze is higher than that of other bronzes. It has exceptional resistance to corrosion. Both its yield point and fatigue limit are high. It has good resilience to heat and cold. By hardening the precipitation, this can be heated-treated. after it is soft, it has good formability, and after it is hardened, it has high fatigue and creep resistance. However, it is expensive.

Applications

For the production of electrical contacts, heavy duty switches, cams, and bushings, as well as springs, tubes, diaphragms, and electrical contacts, beryllium bronze is a particularly suitable material. This is employed for bushings, cams, and heavy-duty electrical switches. Because of its non-sparking properties, it is utilized to make chisels and hammers that are employed in situations where a spark could result in an explosion. It is more suited as a bearing metal since it forms films and has a soft lubricating quality. Because beryllium copper has five times the wear resistance of phosphorous bronze, it is utilized as a bearing metal instead of the latter[10], [11].

Manganese Bronze

An alloy of copper, zinc, and a small amount of manganese is known as manganese bronze. This bronze typically contains 60% copper, 35% zinc, and 5% manganese. Manganese bronze has a high level of corrosion resistance. It is more resilient and durable than phosphor bronze.

Applications

The primary applications for manganese bronze include bushes, plungers, feed pumps, and rods. This bronze is widely used to make worm gears.

Aluminum Bronze

Have aluminum bronze Cu=85 to 88% Al=8 to 11% Fe=3% Sn=0.5%.

Properties

The 8% aluminiumaluminium bronze has excellent cold working characteristics. This metal's mechanical characteristics are significantly enhanced when iron is added by fine-tuning the grain size and enhancing the ductility. This alloy has a 450 MPa maximum tensile strength and contains 11% aluminium. Although this material has good corrosion resistance, the oxidation issue makes casting it relatively challenging.

CONCLUSION

In conclusion, because of their remarkable qualities and wide range of uses, non-ferrous metals are essential to many different industries. These metals, which include titanium, copper, aluminum, zinc, lead, and lead offer special benefits like electrical conductivity, low weight, and corrosion resistance. They are extensively used in industries like power generating, construction, automotive, aerospace, and electronics. The adoption of sustainable practices in the production and use of non-ferrous metals is also rising in importance as sustainability becomes a top priority. Recycling techniques are being used to conserve natural resources, cut down on energy use, and produce less garbage. Additionally, initiatives are being made to enhance extraction methods and lessen the negative effects of mining and refining non-ferrous metals on the environment.

REFERENCES

[1] G. D. Gautam and A. K. Pandey, “Pulsed Nd:YAG laser beam drilling: A review,” *Optics and Laser Technology*. 2018. doi: 10.1016/j.optlastec.2017.09.054.

[2] A. Nath, S. V. Barai, and K. K. Ray, “Prediction of asymmetric cyclic-plastic behaviour for cyclically stable non-ferrous materials,” *Fatigue Fract. Eng. Mater. Struct.*, 2019, doi: 10.1111/ffe.13124.

[3] A. P. Harsha and D. K. Bhaskar, “Solid particle erosion behaviour of ferrous and non-ferrous materials and correlation of erosion data with erosion models,” *Mater. Des.*, 2008, doi: 10.1016/j.matdes.2008.03.016.

[4] M. K. Gupta and V. Singhal, “Review on materials for making lightweight vehicles,” *Mater. Today Proc.*, 2021, doi: 10.1016/j.matpr.2021.02.517.

[5] T. Y. Zuo and T. J. Dai, “Sustainable development of non-ferrous materials industry

and recycling economy," *Zhongguo Youse Jinshu Xuebao/Chinese J. Nonferrous Met.*, 2008.

[6] C. Natarajan, S. Muthu, and P. Karuppuswamy, "Prediction and analysis of surface roughness characteristics of a non-ferrous material using ANN in CNC turning," *Int. J. Adv. Manuf. Technol.*, 2011, doi: 10.1007/s00170-011-3343-1.

[7] R. Zol Bahri and I. Nur Hadzwan, "Automated Green Sorting Device for Ferrous and Non-Ferrous Material Wastes Using Eddy Current Technique," *Appl. Mech. Mater.*, 2015, doi: 10.4028/www.scientific.net/amm.754-755.576.

[8] S. R. Ramalingam, C. S. Boopthi, S. Ramasamy, M. Ahsan, and J. Haider, "Induction heating for variably sized ferrous and non-ferrous materials through load modulation," *Energies*, 2021, doi: 10.3390/en14248354.

[9] R. Anctil, S. D. Grimm, and M. M. Maloney, "Atlas managerial accounting case: Examining joint products in the international scrap metal recycling industry," *J. Account. Educ.*, 2020, doi: 10.1016/j.jaccedu.2020.100660.

[10] T. W. Kim, D. M. Kang, and J. S. Kwak, "Application of magnetic abrasive polishing to composite materials," *J. Mech. Sci. Technol.*, 2010, doi: 10.1007/s12206-010-0323-6.

[11] A. Nath, S. V. Barai, and K. K. Ray, "A generalized model towards predicting monotonic and cyclic deformation behavior of cyclically stable materials," 2019. doi: 10.1016/j.prostr.2020.01.097.

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A DISCUSSION ON PATTERN AND CORE MAKING

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ABSTRACT

Making patterns and cores is a vital procedure in foundry operations that is essential to the creation of intricate metal castings. An overview of the importance of pattern and core making is given in this abstract, with particular emphasis on how they affect the castings' dimensional precision, structural soundness, and all-around excellence. The need of knowledgeable pattern makers and core specialists in the foundry business is emphasized as well as the methods and materials utilized in pattern and core production. Making patterns entails creating exact reproductions, or patterns, that are then utilized to create casting molds. Skilled pattern makers produce patterns that precisely replicate the desired shape, size, and surface polish of the final casting using a variety of materials, including wood, metal, or plastic. To maintain correct molten metal flow during casting, patterns are often created with tolerances for shrinkage, draught angles, and gating devices.

KEYWORDS: *Casting, Mold, Pattern, Piece, Sand, Wax.*

INTRODUCTION

A pattern is a model or a copy of the item that will be cast. It is covered in molding sand, which is appropriately rammed up around the pattern. The design is then taken out and used to create a mold in molding sand. Thus, it is a tool for creating molds. A pattern is similar to a model or a reproduction of the item that will be cast, with the exception of a few minor differences, because it closely matches the casting that will be manufactured. It might be described as a model or form that is surrounded by sand packing to create a cavity known as the mold cavity into which molten metal is poured to produce the cast object. Molten metal solidifies when it is poured into this mold or cavity, creating a casting (product). Consequently, the pattern is a copy of the casting[1]–[3].

For the aim of creating a casting, a pattern prepares a mold cavity. In order to create additional recesses in the mold for the insertion of core to produce smoothness in casting, it may additionally have projections known as core prints. It might be useful in creating a seat for the positioning of the core at specific locations on the mold in the shape of an additional recess. In the mold, it establishes the separating line and parting surfaces. Before the molding sand is rammed, it might be helpful to locate a core in the event that a mold cavity contains cores. It ought to have polished and smooth surfaces to minimize casting flaws. Runners, gates, and risers that are used to introduce and feed molten metal into the mold cavity can occasionally serve as the pattern's component pieces. Making patterns is the first stage in casting. The mold is created using a pattern formed of a suitable material and molding sand or another suitable mold material. It creates a replica of the pattern when the mold is filled with molten metal and allowed to harden; this process is called casting. There are a few goals for a pattern that are listed below.

Objectives of Pattern

For the goal of creating a casting,

1. Pattern prepares a mould cavity.
2. The pattern has core prints that result in seats that are extra recesses for placing cores in the mould.
3. In the mould, it establishes the separating line and parting surfaces.
4. The pattern may have Runner, Gates, and Riser.
5. Well-built patterns reduce the casting's overall cost.
6. In order to check the casting dimensions, a pattern may be used to set up locating pins on the mould and therefore on the casting.
7. Casting flaws are reduced by properly prepared patterns with polished and smooth surfaces.

Typically, patterns are created in a pattern shop. The overall cost of the castings may be reduced by using the right pattern and material in their manufacturing.

Common Pattern Materials

Patterns are frequently made from wood, metal, plastic, plaster, wax, or mercury. Below are some key pattern materials that are covered.

Wood

The most prevalent and well-liked material for producing patterns is wood. It is inexpensive, readily accessible, repairable, and quickly constructed into a variety of shapes using resin and glues. It may create surfaces that are extremely smooth and is quite light. Shellac can be used on wood to maintain the surface and extend the life of the design. Despite the aforesaid features, it is prone to warping and shrinking, and its lifespan is limited since the molding sand's wetness has a significant impact on it. It warps and deteriorates quickly after some use because it is less resistant to sand abrasion. It is weak compared to metal and cannot handle adversity well. In light of the aforementioned characteristics, wooden designs are only preferable when fewer castings need to be created. Shish am, Kail, Deodar, Teak, and Mahogany are the principal types of wood used in pattern-making.

Shisham

It has golden and dark brown stripes and is dark brown in color. It is extremely difficult to work with and quickly blunts the cutting tool when cutting. It is incredibly robust and long-lasting. Along with producing patterns, it is also employed in the production of a wide range of furniture, including mattresses, cabinets, plywood, tool handles, and furniture.

Kail

It is too tangled up. It grows in the Himalayas and produces a close-grained, medium-hard, and long-lasting wood. It is highly paintable. In addition to making patterns, it is also used to create inexpensive furniture, wooden doors, and packing cases.

Deodar

When it is soft, it is white in color, but when it gets hard, it turns light yellow. It is sturdy and long-lasting. When smelled, it emits aroma. Since it contains some oil, insects are less likely to attack it. It can be found in the Himalayas at elevations between 1500 and 3000 meters. It is employed in the production of doors, furniture, patterns, railway sleepers, and other items. Given its close grain structure and softness, it is unlikely to bend. It is inexpensive and simple to implement. It is preferred for creating patterns for small-scale, low-volume casting manufacturing[4]–[6].

DISCUSSION

Some other common pattern materials:

Teak Wood

It is hard, extremely expensive, and comes in dark brown or golden yellow. Its unique stripes enhance its charm. It can be found in M.P. in India. It has numerous applications and is extremely strong and long-lasting. It may keep its polish well. In addition to making patterns, it is employed in the production of high-quality ships, plywood, and furniture. It is a light wood with a straight grain. It is readily manipulated and does not warp much. Its price is reasonable.

Mahogany

This wood is robust and durable. Compared to the previously described woods, this wood's patterns are more resilient and less likely to deform. It may be easily formed into many different shapes and has a homogeneous straight grain structure. It is more expensive than teak and pine wood, and it is typically not chosen for its excellent accuracy when creating intricate patterns. Additionally, it is preferred for the manufacturing of small-scale, low-volume castings. Deodar, Walnut, Kail, Maple, Birch, Cherry, and Shish am are some other Indian woods that can be utilized for pattern-making.

Advantages of wooden patterns

1. Wood is easily workable.
2. It is not too heavy.
3. Access to it is simple.
4. The cost is relatively low.
5. It is simple to sign up.
6. Achieving a high-quality surface finish is simple.
7. Strong wooden laminated patterns.
8. It is easy fixable.

Disadvantages

1. 1 It is moisture-sensitive.
2. It is prone to warping.
3. Sand abrasion causes it to deteriorate quickly.

4. It is less durable than metallic designs.

Metal

When there will be a sufficient quantity of castings needed, metallic patterns are selected. As opposed to wooden patterns, these patterns are less susceptible to dampness. This pattern experiences extremely little wear and tear and has a longer lifespan as a result. Additionally, it is simpler to create patterns in metal with good precision, a smooth surface, and intricate shapes. For a longer time, it can survive handling and corrosion. It has a fantastic strength to weight ratio. The primary drawbacks of metallic patterns are their higher cost, heavier weight, and propensity to rust[7]–[9]. For the manufacturing of identical-pattern castings in large quantities, it is preferred. Cast iron, brass, bronze, and aluminum alloys are the metals that are frequently used to create patterns.

Cast Iron

It can create a flawless surface finish and is less expensive, stronger, tougher, and more lasting. Additionally, it has strong resistance against sand abrasion. Cast iron patterns have the disadvantages of being heavy, brittle, rigid, and prone to rusting when exposed to moisture.

Advantages

1. The price is low.
2. It's simple to fit and file
3. It is powerful.
4. It has good sand abrasion resistance.
5. A smooth surface

Disadvantages

1. It is heavyweight.
2. It is brittle and hence it can be easily broken.
3. It may rust.

Brasses and Bronzes

These are preferred for producing small castings since they are heavier and more expensive than cast iron. They are machinable, strong, and resistant to corrosion and wear. They are able to create better surface finishes. Making match plate patterns uses patterns made of brass and bronze.

Advantages

1. Cast iron has a better finish on the surface.
2. It is simple to cast parts that are quite thin.

Disadvantages

1. It is expensive
2. It weighs more than cast iron does.

Aluminum Alloys

Because of their great lightness, good surface quality, low melting point, and good strength, aluminum alloy patterns are the most well-liked and best of all metallic patterns.They also have good resistance to corrosion and sand abrasion, which prolongs the life of the pattern. These materials are not durable when handled roughly. These are preferred for creating massive castings despite having poor reparability.

Advantages

1. The pattern of aluminum alloys does not rust.
2. Casting them is simple.
3. They weigh very little.
4. They are simple to machine.

Disadvantages

1. Sharp edges have the potential to hurt them.
2. They are more malleable than cast iron and brass.
3. Care must be used when storing and transporting them.

White Metal

Advantages

1. It works well as a liner and stripping material for plates.
2. Its low melting point is approximately 260°C.
3. It can be poured into small crevices.

Disadvantages

1. It's too supple.
2. It requires careful storing and shipping.
3. Sand or jagged edges wear it down.

Plastic

The patterns formed of plastics are lighter, stronger, moisture and wear resistant, non-stick to molding sand, durable, and unaffected by the wetness of the molding sand, which is why they are becoming more and more popular today. Additionally, they provide the pattern surface an extremely smooth surface finish. These materials could have metal reinforcement because they are a little brittle, less able to withstand unexpected loading. The thermosetting resins that are utilized as plastics for this purpose. Plastics made from phenolic resin are widely utilized. These start off as liquids and solidify when heated to a certain temperature. With the use of a wooden pattern known as a master pattern, a mold in two halves is created in plaster of Paris to prepare a plastic pattern. After pouring the phenolic resin into the mold, the mold is heated. The plastic design is created when the resin solidifies. Foam plastic, a new substance that has recently entered the plastics industry. Expandable polystyrene plastic is the most popular type of foam plastic currently being made. Benzene and ethyl benzene are used in its production.

Plaster

This substance is a member of the gypsum family, which lends itself well to casting and working with wooden tools to produce castings with exquisite details. Plaster's key benefits are its high compressive strength and high expansion setting type, which make up for the casting metal's allowance for shrinkage. The Plaster of Paris pattern can be created by either pouring the plaster and water slurry directly into molds that have already been made using a master pattern or by sweeping it into the appropriate shape or form using the sweep and stickle technique. Additionally, it is preferred for the creation of complicated small-scale castings and core boxes.

Wax

Wax patterns work quite well for the investment casting process. The components consist of mixtures of several wax kinds and other additives that serve as polymerizing agents, stabilisers, etc. Paraffin wax, shellac wax, beeswax, ceresin wax, and micro-crystalline wax are among the most widely used waxes. Low ash content (up to 0.05%), resistance to the primary coat material used for investment, high tensile strength and hardness, and significant weld strength are all required qualities in a good wax pattern. Wax is often injected into a split die in liquid or semi-liquid form to create wax patterns. Additionally, solid injection is employed to improve strength and prevent shrinkage. Castings with a high level of surface finish and dimensional accuracy benefit from the use of waxes. Heated wax is poured into split molds or a pair of dies to create wax patterns. The dies are separated once they have cooled down. The wax design has now been removed and is being utilized for molding. Such patterns don't have to be solidly drawn from the mold. When the mold is prepared, the wax is poured out by heating the mold while maintaining it in an upside-down position. These patterns are typically employed in the process of investment casting, where accuracy is correlated with object complexity**.**

Factors affecting selection of material

When choosing pattern materials, the following elements must be taken into account.

1. The quantity of castings that will be made. When many castings are needed, metal patterns are preferred.
2. The material used to make the mold.
3. A molding technique.
4. The molding technique (manual or automated).
5. Required level of surface polish and dimensional correctness.
6. Required thickness minimum.
7. The casting's size, complexity, and shape.
8. Pattern price and likelihood of repeat purchases.

Types of Pattern

The types of the pattern and the description of each are given as under.

1. One piece or solid pattern
2. Two piece or split pattern

3. Cope and drag pattern
4. Three-piece or multi- piece pattern
5. Loose piece pattern
6. Match plate pattern
7. Follow board pattern
8. Gated pattern
9. Sweep pattern
10. Skeleton pattern
11. Segmental or part pattern

Single piece pattern

Without joints, separating lines, or loose parts, a solid design is constructed of a single piece. It is the pattern's most basic variation.Figure 1 shows single piece pattern.

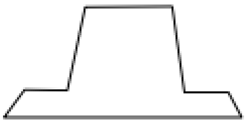

Figure 1: Shows single piece pattern (wordpress.com).

Two piece or split pattern

Solid patterns are broken into two pieces when they are challenging to remove from the mold cavity. Dowel pins are used to unite the two halves of the split pattern at the separating line. To make the pattern pullout easier, the pattern is split at the parting line.Figure 2 shows two piece pattern.

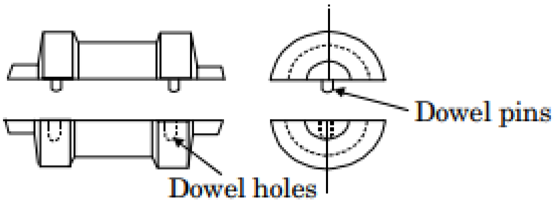

Figure 2: Shows two-piece pattern(wordpress.com).

Cope and drag pattern

The cope and drag portions of the mold are made independently in this instance. When the entire mold is too heavy for one operator to lift, this is what is done. The design consists of two parts that are put on several plates.Figure 3 shows cope and drag pattern.

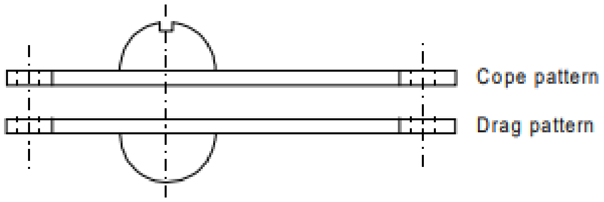

Figure 3: Shows cope and drag pattern (wordpress.com)

Three piece or multi piece pattern

Some patterns are difficult to extract because of their intricate shapes, thus they cannot be constructed in one or two pieces. Because of this, these patterns are either produced in three sections or in several portions. To create a mold using these patterns, many molding flasks are required.

Loose-piece pattern

When it is difficult to remove the pattern from the mold, loose piece patterns are utilized. The design includes loose elements, which constitute a component of the pattern.The loose piece section of the pattern is left in the mold after the main pattern has been removed. Finally, the loose piece is removed individually from the complex mold.Figure 4 shows loose piece pattern

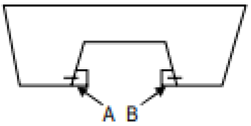

Figure 4:Shows loose piece pattern(wordpress.com)

Match Plate Pattern

The match plate, a wooden or metallic plate with this design affixed on the opposing sides, is comprised of two parts. The plate is also affixed to the gates and runners. Utilizing this design in machine molding complex mold.Figure 5 shows match plate pattern.

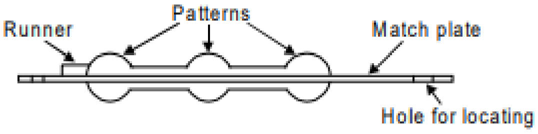

Figure 5: Shows match plate pattern(wordpress.com)

Follow board pattern

When using solid or split patterns becomes challenging, a wooden board known as a follow board is contoured to precisely match the shape of one half of the pattern and serves as a molding board for the initial molding process, as shown[10]–[12]. Figure 6 shows follow board pattern.

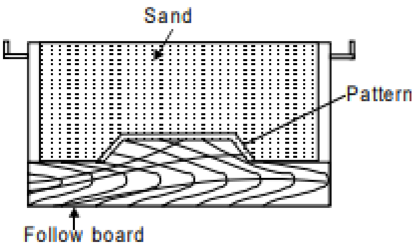

Figure 6: Shows follow board pattern (wordpress.com)

CONCLUSION

Making patterns and cores is a crucial part of foundry operations since it directly affects the integrity and quality of metal castings. To ensure that the final castings satisfy the required standards, correct patterns and cores must be produced by skilled pattern makers and core technologists. Making precise patterns ensures that the castings specified shape, size, and surface finish will be faithfully reproduced in the molds. When creating patterns, skilled pattern designers take into account variables including shrinkage, draught angles, and gating systems to promote optimum metal flow and reduce casting flaws. By generating sand cores with elaborate shapes or interior voids, core manufacturing adds to the intricacy and structural stability of castings. In order to guarantee that the cores are appropriately hardened, vented, and positioned within the mold, core specialists use specialized processes and materials.

REFERENCES

[1] E. S. Almaghariz *et al.*, “Quantifying the role of part design complexity in using 3d sand printing for molds and cores,” *Int. J. Met.*, 2016, doi: 10.1007/s40962-016-0027-5.

[2] B. Chokkalingam, S. Boovendravarman, R. Tamilselvan, and V. Raja, “Application Of Ishikawa Diagram To Investigate Significant Factors Causing Rough Surface On Sand Casting,” *Proc. Eng. Sci.*, 2020, doi: 10.24874/PES02.04.002.

[3] L. N. Groschner, L. Chan Wah Hak, R. Bogacz, S. DasGupta, and G. Miesenböck, “Dendritic Integration of Sensory Evidence in Perceptual Decision-Making,” *Cell*, 2018, doi: 10.1016/j.cell.2018.03.075.

[4] H. E. Joo, S. J. Han, M. K. Park, and K. S. Kim, “Shear tests of deep hollow core slabs strengthened by core-filling,” *Appl. Sci.*, 2020, doi: 10.3390/app10051709.

[5] L. Akenji and M. Bengtsson, “Making sustainable consumption and production the core of sustainable development goals,” *Sustain.*, 2014, doi: 10.3390/su6020513.

[6] N. Wang, J. Li, and Z. Zhou, “Landscape pattern optimization approach to protect rice terrace Agroecosystem: Case of GIAHS site Jiache Valley, Guizhou, southwest China,” *Ecol. Indic.*, 2021, doi: 10.1016/j.ecolind.2021.107958.

[7] C. Chelladurai, N. S. Mohan, D. Hariharashayee, S. Manikandan, and P. Sivaperumal, “Analyzing the casting defects in small scale casting industry,” 2020. doi: 10.1016/j.matpr.2020.05.382.

[8] S. Sharma, V. Ucharia, C. Sharma, and R. Singh Kanwar, “Investigation And Analysis

Of Metal Casting Defects By Using Quality Control Tools," *Ind. Eng. J.*, 2018, doi: 10.26488/iej.11.5.1067.

[9] S. Renner, M. S. Dalzochio, E. Périco, G. Sahlén, and J. Suhonen, "Odonate species occupancy frequency distribution and abundance–occupancy relationship patterns in temporal and permanent water bodies in a subtropical area," *Ecol. Evol.*, 2020, doi: 10.1002/ece3.6478.

[10] X. Wang, F. G. Blanchet, and N. Koper, "Measuring habitat fragmentation: An evaluation of landscape pattern metrics," *Methods Ecol. Evol.*, 2014, doi: 10.1111/2041-210X.12198.

[11] C. Le Heron *et al.*, "Distinct effects of apathy and dopamine on effort-based decision-making in Parkinson's disease," *Brain*, 2018, doi: 10.1093/brain/awy110.

[12] M. M. Rogers-Carter, A. Djerdjaj, K. B. Gribbons, J. A. Varela, and J. P. Christianson, "Insular cortex projections to nucleus accumbens core mediate social approach to stressed juvenile rats," *J. Neurosci.*, 2019, doi: 10.1523/JNEUROSCI.0316-19.2019.

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A BRIEF STUDY ON PLANT AND SHOP LAYOUT

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ABSTRACT

Effective plant and shop layout design plays a significant role in optimizing operations and boosting efficiency in manufacturing and retail sectors. This abstract gives an overview of the important concerns and advantages connected with an efficient plant and shop architecture. The design of a plant layout includes organizing machinery, equipment, workstations, and other resources in an efficient and logical way to support the seamless flow of commodities, information, and people. Similarly, store layout design focuses on structuring retail areas to maximize customer experience, boost product exposure, and expedite the shopping process.

KEYWORDS: *Layout, Material, Plant, Production, Product.*

INTRODUCTION

In a manufacturing organization, a task to be produced spends most of the time in moving and waiting. For decrease of this movement and waiting time of jobs/parts, it is vital to have suitable layout and correct scheduling technique. Plant layout describes the location of the general organization of the different facilities such as equipment's, material, labor, materials handling, service facilities, and passage necessary to support effective operation of production system of the plant within the area of the site designated before. Shop layout in manufacturing plant also constitutes a vital aspect of factory planning or plant layout. Plant planning starts with the design the place of the factory building and continues up to the positioning and movement of a work table of the machine. All the production facilities such as equipment's, raw materials, machinery, tools, fixtures, personnel, etc. are given a correct position in each shop of the manufacturing facility. Plant layout of an industrial organization plays a significant part in scientific management and is characterized as plant layout is such a systematic and efficient functional arrangement of various departments, machines, tools, equipment and other supports services of an industrial organization that will facilitate the smooth processing of the proposed or undertaken product in the most effective, most efficient and most economical manner in the minimum possible time[1]–[3].

Plant layout of an industrial organization comprises of all the aspects connected with the industrial enterprise, viz., grounds, buildings, machinery, equipment, departments, methods of manufacturing, factory services, material handling, flow of production, working conditions, hygiene, labor and shipment of goods, etc. It may not necessary entail planning a new enterprise exclusively. However, it also incorporates modest changes, here and there, in the current layout, extension of the outgoing plant, re-layout of the existing plant and layout of a new proposed facility. In a best possible plant structure, material handling and transportation is minimized and effectively regulated. Bottlenecks and sites of congestions are avoided so that the raw material and semi-finished items flow swiftly from one work station to another. Work stations are created adequately to support the seamless processing of the intended or undertaken product in the most effective, most efficient and most inexpensive way in the minimum possible time. Optimal spaces are given to manufacturing centers and service centers. The primary purpose of plant layout is to maximize profits by putting up the finest feasible arrangements of all plant facilities to the utmost benefit of decreasing the cost of manufacturing of the proposed product.

Objectives of good plant layout

Good plant layout contains the best feasible arrangement of the buildings, workers, equipment and materials for processing an under taken product. The main objectives of a good plant layout involve minimum material movement, smooth flow of the product in the plant, full utilization of the space of the plant, provide adequate safety and satisfaction to the plant workers, evolve sufficient flexibility in the arrangement of the above factors so as to suit the minor future changes, if any and facilitates an effective supervision. It helps to combine all the above factors in such a manner that the optimal compromise and coordination among them is accomplished.

The movements of employees and manufacturing staffs inside the facility are limited. Waiting time of the semi-finished and final items should be minimized to the minimum. Working conditions as far as practicable should be safer and better for the satisfaction of the employees. There should be an improved flexibility for modifications in product design and for future growth. There should be complete use of the area of the shop and plant layout. The work methods and decreased production cycle times should be enhanced and the plant maintenance must be simplified. There should be higher production and better product quality with reduced capital expense. A suitable layout permits materials to pass through the facility at the desired pace with the smallest feasible cost.

Important factors for installation of a plant

The important factors while planning for installation of plant include availability of space, power, water, raw material, good climatic conditions, good means of communication, ancillaries, low local taxes and similar other economic considerations, marketing facilities for the planned product, space for process disposal and skilled and unskilled labor locally. One needs to bear in mind the possibilities of usage and sale of the process wastes and by-products of the planned enterprise. Decision of producing new product, financial and other aids, facilities for growth presence of linked industries, local by laws and regulations, hospitality are also important aspects which one must bear in mind for site of an organisation.

After finalizing the size and location of the plant, the next step is to design the inner layout of the plant to plan out the sequence of different shops and their locations accordingly to specifications of material and product, manufacturing processes, type of production, material handling facilities, system and facilities for storing, inter-dependability of one shop over the other, links among various shops, service facilities and lighting and ventilation. Next, the interior arrangement of the previously specified infrastructural facilities of distinct stores arerecognised. This identification is referred as store layout. The main factors namely size and type of equipment, number of machines to be installed, floor area required for working on each machine, power requirements for the machines, requirements of factory services, sequence of operations to be followed, visibility to all the machines for proper supervision and control, type of drive used, safe working conditions, provision of stores within the shop, i.e. for tools, instruments, finished parts and consumable materials, etc. affects the layout of the plant. A good plant layout should fulfil the following fundamental need[4]–[6]

1. Integration of production centre facilities in terms of man, machine and material.
2. Movements of production staff and material handling should be reduced.
3. Smooth and continuous flow of production or manufacturing activities with least possible bottlenecks and congestion spots.
4. Floor space usage should be ideal as far as practicable.
5. Working place should be free from pollution and safe working conditions shall prevail in each shop of the plant.
6. The management of raw material, half completed and final product should be should be addressed efficiently and effectively.
7. Plant plan and shop layouts must be adaptable to allow changes in production requirements.
8. There should be improved working environment in term of appropriate light, ventilation and other facilities such as drinking water and bathrooms for welfare for the manufacturing employees.

DISCUSSION

Merits of a good plant layout

The main advantages of a good plant layout involve effectively and economical utilization of entire floor space of the plant, increased rate of production, reduced men and machine hours per unit of production, reduced material handling, minimal production delays, effective utilization of men, machinery, material and other factory support services, reduced overall production time, elimination of large amount of paper work, significant reduction in the indirect expenses, considerable reduction in inventory work for material, promote effective supervision, facilitate easy flow of men, tools and material, promote flexibility in arrangement to suit the future changes, promotes better planning and effective control, facilitates better and easier maintenance of plant and machinery, provides safer and healthier working conditions thereby improving the morale of the workmen, provides the material as well as psychological satisfaction to the workers and enhance overall efficiency of the plant. The key benefits of a good plant layout are described as under:

1. Reduced men and machine hours per unit of production,
2. Effectively and economic exploitation of total floor area of the plant,
3. Work flow is seamless and continuous
4. Work in progress inventory is less
5. Production control is better
6. Manufacturing time is shorter
7. Relatively less floor area is needed
8. Material handling is less.

Types of layout

The satisfying the goals of a good layout as per each product demand and product types, the layouts are grouped into four key categories including fixed or position layout, line or product layout, process or functional layout and combination or group layout. Each kind of layouts is detailed with corresponding merit, demerits and application as following:

1. Fixed or position layout

In this form of arrangement, the primary component of an assembly or material stays at a fixed position. All its accessories, supplementary material, machinery, equipment needed, tools required and the workforce are carried to the fixed location to work. Thus, the product by virtue of its bulk or weight stays in one spot. Therefore the placement of the principal assembly, semi assembly component and material is not disturbed until the product is ready for shipment. This layout is useful when one or a few components of an item are to be created and material forming or treatment activity needs just tools or basic machinery. This structure is highly preferable when the expense of transporting the principal piece of material is high and the responsibility of product quality by one skilled workman or group of expert employees is required. This type of style is typically employed for very huge things made in very small quantity such as ships, aero aircraft, boilers, reactors etc. It key virtue of this layout is the minimum movement of workers, material, and tooling throughout production process. This layout is high flexible since the kind of product and the associated procedures may be simply changed without any change in the layout [7]–[9].

1. Merits
2. Its primary benefits are
3. Pattern is very adaptable for types of goods with intermittent demand since the type of product and the associated processes may be readily adjusted without any change in the pattern.
4. There is a minimal movement of workers, material, and tooling throughout manufacturing process.
5. 3. The substance is considerably decreased.
6. 4. Highly trained operators are needed to accomplish the task at one point and responsibility for quality is focused on one person or the assembly team.
5. Every individual of production team is accountable for quality job for producing the product.

Demerits

1. The cost of equipment handling is relatively high.
2. Labors and equipment’s are tough to employ completely.
3. It is confined to big things only.

2. Process or functional layout

In this form of layout arrangements of comparable machinery, industrial facilities and manufacturing activities are placed together according to their purposes. Machine tools of one kind are positioned together so that all the similar operations are performed always at the same place e.g. all the lathes may be grouped together for all kinds of turning and threading operations, all drilling machines in one area for carrying out drilling work, all tapping machines in one area for carrying out tapping work, all milling machines in one area for carrying out milling work all buffing and polishing machines at one place for carrying out surface finishing work, and so on. This form of layout is typically favoured for the industries engaged in work order type of production and manufacturing and/or maintenance operations of non- repetitious type. This layout should not to have to be updated every time of the product or component modifications. Also the failure of any machine does not effect the output. This sort of setup is extremely ideal for batch production.

1. Merits
2. There exists a broad flexibility regarding distribution of work to equipment and employees.
3. There is a better usage of the available equipment.
4. Comparatively reduced numbers of machines are required in this architecture and so thus reducing capital expenditure.
5. There is an enhanced product quality, since the supervisors and employees attend to one kind of machinery and processes.
6. Varieties of tasks arriving as diverse job orders therefore make the work more interesting for the workforce.
7. Workers in one sector are not influenced by the nature of the activities carried out in another section. For example, a lathe operator is not impacted by the rays of the welding since the two portions are relatively distinct.

Demerits

1. This arrangement demands greater area in contrast to line or product layout for the same quantity of production.
2. Production control becomes rather tough in this setup.
3. Raw material has to travel further which increases material handling and the associated costs.
4. This arrangement demands more effective co-ordination and inspections.
5. Increased material handling cost owing to greater transfer of process raw material to various pathways.
6. More material in progress stays in line for further operations.
7. Requires huge in-process inventory.
8. Completion of same product takes more time.

3. Line or Product Layout

This pattern suggests that numerous operations on raw material are conducted in a sequence and the machines are located along the product flow line, i.e., machines are organised in the order in which the raw material will be operated upon. In this style of arrangement all the machines are organised in a line according to the sequence of operations, i.e., each following machine or section is designed to conduct the next operation to that done by its previous machine or part. In this architecture raw material begins at one end of manufacturing lines and goes from one machine to another along a sequential route. Line layout has advantageous in the continuous- production system when the number of end products is minimal and the components are highly standardized and interchangeable.It is excellent for items with stable demand. This plan may contain operating sequence namely forging, turning, drilling, milling, grinding and inspection before the product is sent to the finished products store for packaging and transportation. This arrangement is utilised for large production and enables seamless flow of materials and decreased material handling. Breakdown of any machine in the line with this architecture may result in even halt of production.

1. Merits
2. It features smooth and continuous work flow.
3. It may need fewer skilled people.
4. It aids in lowering inventory.
5. Production time is decreased with this arrangement.
6. Better coordination, simplified production planning and management are obtained with this layout.
7. For the same quantity of output, reduced room required for this arrangement.
8. Overall processing time of goods is extremely low.
9. This concept incorporates automated material handling, reduced material movements and hence leads to minimal feasible cost of production.

Demerits

1. It is exceedingly difficult to raise output beyond the limitations of the manufacturing lines.
2. When one inspector needs to watch after multiple equipment, inspection becomes tough.
3. This layout is substantially less versatile for product modification.
4. The rate or pace rate of working relies upon the output rate of the slowest machine and thereby leads to unnecessary idle time for other machines if the production line is not correctly balanced.
5. Machines being set up along the line, additional machines of each kind have to be installed for maintaining a few as stand by, since if on machine in the line fails, it may lead to shut down of the full production line. That is why the line or product layout entails large capital expenditures.

4. Combination Layout

It is also known as group layout. A mix of process and product layouts combine the benefits of both kinds of layouts. Most of the production sections are arranged in process layout with manufacturing lines occurring here and there scattered wherever the circumstances permit. These days, the bulk of industrial businesses have adopted this style of structure. In this sort of arrangement, a set of machinery or equipment is grouped together in a section, and so on, such that each set or group of machines or equipment is used to execute similar operation s to generate a family of components. A combination arrangement is feasible if an object is being created in several kinds and sizes. In such circumstances, machinery and manufacturing equipment's are put in a process layout buta group of number of similar machines is then arranged in a sequence to create different kinds and sizes of products. In this arrangement, it is noticed that, no matter the product differs in size and kind, the sequence of processes stay same or comparable. This pattern is ideal when comparable activities are conducted together so minimizing wasting time in transitioning from one unrelated activity to the next. It focuses on minimizing needless repetition of an effort. It is suitable for storing and accessing information changing connected to reoccurring issues so reducing the search tin comprehending information and removing the need to address the problem again. It is also beneficial when a lot of products are manufactured in identical sequence but none of the items are to be produced in bulk and therefore no item warrants for an individual and independent production line[10]–[12].

Merits

1. Reduction in cost of machine set-up time and material handling of metals.
2. Elimination of superfluous work-in-process inventory which subsequently permits the reduction in lot size.
3. Simplification of production planning functions, etc.

Demerits

1. Change of the present layout is time consuming and expensive.
2. Inclusion of new components in the current component demands extensive examination.
3. Modification of input component mix may probable to modify full layout structure.
4. Effect of batch size may affect number of machines.

CONCLUSION

An optimal plant and shop architecture is vital for boosting efficiency, productivity, and profitability in manufacturing and retail businesses. By examining aspects like workflow patterns, equipment location, material handling, and customer experience, organizations can design layouts that expedite operations, decrease costs, and create a favorable atmosphere for both staff and consumers. With the assistance of sophisticated technology, the design and optimization process continue to improve, allowing firms to remain competitive in today's dynamic marketplace

REFERENCES

[1] P. Mallick, K. Muduli, J. N. Biswal, J. Pumwa, and P. Oyekola, "Development of a suitable plant layout using computerised relative allocation of facility techniques," *Int. J. Recent Technol. Eng.*, 2019, doi: 10.35940/ijrte.B1070.078219.

[2] R. D. Vaidya, P. N. Shende, N. A. Ansari, and S. M. Sorte, "Analysis Plant Layout for Effective Production," *Int. J. Eng. Adv. Technol.*, 2013.

[3] G. Kovács, "Layout design for efficiency improvement and cost reduction," *Bull. Polish Acad. Sci. Tech. Sci.*, 2019, doi: 10.24425/bpasts.2019.129653.

[4] N. Hari Prasad, G. Rajyalakshmi, and A. Sreenivasulu Reddy, "A typical manufacturing plant layout design using CRAFT algorithm," 2014. doi:

10.1016/j.proeng.2014.12.334.

[5] S. L. Yang, Z. G. Xu, and J. Y. Wang, "Modelling and production configuration optimization for an assembly shop," *Int. J. Simul. Model.*, 2019, doi: 10.2507/IJSIMM18(2)CO10.

[6] S. Khariwal, P. Kumar, and M. Bhandari, "Layout improvement of railway workshop using systematic layout planning (SLP)-A case study," 2020. doi: 10.1016/j.matpr.2020.10.444.

[7] N. Hammouche and R. Stark, "Digital twin for the plant layout – updating the layout data of production plants with a focus on the operating equipment," *WT Werkstattstech.*, 2021, doi: 10.37544/1436-4980-2021-03-80.

[8] T. Nurainun and A. Sulistyawan, "Perancangan Ulang Tata Letak Fasilitas Pada Sistem Produksi Flow Shop (Studi Kasus Pt. Xxx Pekanbaru)," *Semin. Nas. Teknol. Informasi, Komun. dan Ind.*, 2018.

[9] P. A. Wrigley, P. Wood, P. Stewart, R. Hall, and D. Robertson, "Module layout optimization using a genetic algorithm in light water modular nuclear reactor power plants," *Nucl. Eng. Des.*, 2019, doi: 10.1016/j.nucengdes.2018.10.023.

[10] P. R. Akkoni, V. N. Kulkarniand, and V. N. Gaitonde, "Applications of work study techniques for improving productivity at assembly workstation of valve manufacturing industry," 2019. doi: 10.1088/1757-899X/561/1/012040.

[11] C. Wang, F. Chang, and J. Gao, "Equipmentlayout design of smart job-shop based on AGV unidirectional guided-path network," *Jisuanji Jicheng Zhizao Xitong/Computer Integr. Manuf. Syst. CIMS*, 2020, doi: 10.13196/j.cims.2020.04.008.

[12] M. Manivel and D. Sandeep, "Layout Planning in a Pump Manufacturing Industry Using ARENA," *Int. J. Sci. Eng. Res.*, 2014.

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METHODS OF POWDER METALLURGY PROCESSES

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ABSTRACT

Amanufacturing method known as powder metallurgy uses fine metal powders to create metal parts and components. The main processes, benefits, and applications of powder metallurgy are highlighted in this abstract. The relevance of powder metallurgy as a flexible and affordable process for creating complicated metal objects with improved characteristics is summarized in the conclusion.

KEYWORDS: *Metal, Metallurgy, Powder, Process, Size.*

INTRODUCTION

Using tremendous compressive force, powdered metals are compacted in molds to create products or objects. This process is known as powder metallurgy. Grinding wheels, filament wire, magnets, welding rods, tungsten carbide cutting tools, self-lubricating bearings, electrical connections, and turbine blades with high temperature strength are typical examples of such items. The production of powders, blending, compacting, profiteering, sintering, and a number of auxiliary processes, including sizing, coining, machining, impregnation, infiltration, plating, and heat treatment, are all necessary for the powder metallurgy process to produce parts. In order to bind the particles together and enhance their strength and other attributes, the compressed products are next heated to temperatures well below their melting points. To produce a suitable binding or to impart some of the required qualities, a few non-metallic components can also be added to the metallic powders. Due to the high cost of the dies that are used as well as the metal powders, the products produced using this technique are quite expensive. It is possible to use the powders of practically all metals, a sizable number of alloys, and nonmetals. Only for high mass manufacturing is the use of the powder metallurgy technique commercially viable. Powder metallurgy produces parts with unique characteristics that are impossible to duplicate using traditional techniques. Simple shaped pieces can be sized precisely without waste, and they can be finished or nearly finished for installation[1]–[3].

Powder Metallurgy Process

The basic steps in the powder metallurgy process are as follows:

1. The development of metallic powders.
2. Blending or mixing the metallic granules in the appropriate amounts.
3. Forming the powders into the appropriate shapes and sizes in the form of articles by compressing and compacting them.
4. In a controlled furnace environment, sintering the compressed materials.
5. If necessary, subjecting the sintered products to additional processing.

Production of Metal Powder

Metallic powders with various characteristics can be easily created. Iron- and copper-based powders are the two most often utilized types. However, metal powders made of titanium, chromium, nickel, and stainless steel are also employed. the size of the majority of powders is the particle ranges in size from a few microns to 0.5 mm. Powders typically have particles between 10 and 40 microns in size. The size and shape of the powder particles affect the chemical and physical characteristics of metals. Powders are made using a variety of techniques.The following list includes the most popular methods for creating powder.

1. Atomization
2. Chemical reduction
3. Electrolytic process
4. Crushing
5. Milling
6. Condensation of metal vapor
7. Hydride and carbonyl processes.

1. Atomization

In this procedure, the molten metal is pushed through an opening and, as it exits, is impinged upon by a high pressure stream of gas or liquid, atomizing it into tiny particles. The purity of the powder is then increased by using the inert gas. Due to the metal's corrosive action on the orifice (or nozzle) at high temperatures, it is mostly utilized for low melting point metals like tin, zinc, lead, aluminum, and cadmium. This process can also be used to manufacture alloy powders.

2. Chemical reduction

This method involves reducing metal complexes, such as iron oxides, with CO or H2 in an atmosphere-controlled furnace at temperatures below the metal's melting point. After reduction, the product is crushed and pulverized.

3. Electrolytic process

The electrolysis method, which is somewhat similar to electroplating, is mostly used to create exceedingly pure copper and iron powders. Copper plates are used as anodes in an electrolyte tank to create copper powder, while aluminums plates are used as to serve as cathodes for the electrolyte. The cathodes develop a powdery anode metal deposit under high amperage. The cathode plates are removed from the tank after a predetermined amount of time, rinsed to remove electrolyte, and then dried. In order to create copper powder with the correct grain size, the copper that has been deposited on the cathode plates is scraped off and ground. The electrolytic powder has a high level of oxidation resistance.

4. Crushing

Equipment's like stamps, crushers, or gyratory crushers are needed for the crushing process. It is possible to heat-treat a variety of ferrous and non-ferrous alloys to produce a suitably brittle material that is simple to crush into powder form.

5. Milling Process

Metal powder is frequently produced using the milling process. It is done with the use of machinery like ball mills, impact mills, eddy mills, disc mills, vortex mills, etc. For easier pulverization of brittle, tougher, malleable, ductile, and harder metals, milling and grinding processes can be used. A ball mill is a horizontal, barrel-shaped container with several balls within. As the container rotates, the balls are free to tumble around, crushing and abrading any powder particles added to the container. In order to generate successively finer grades of powder, a huge mass that needs to be ground typically first passes through powerful crushing equipment, then through crushing rolls, and ultimately through a ball mill[4]–[6].

6. Condensation of Metal Powders

Metals like Zn, Cd, and Mg, which can be boiled and the vapors condensed into a powder form, can be used in this method. Typically, a metal rod, such as Zn, is fed into a high-temperature flame, where the vaporized metal droplets are then allowed to condense on a cool surface made of a substance to which they would not stick. This process is not well suited for producing powder on a large scale.

7. Hydride and Carbonyl Process

Tantalum, niobium, and zirconium are examples of high hardness orientated metals that are made to interact with hydrogen to create hydrides that are stable at ambient temperature but start to dissolve into hydrogen and the pure metal at about 350°C. Similarly, it is possible to get nickel and iron to react with CO to generate volatile carbonyls. The carbonyl vapor is subsequently broken down in a chilly chamber, depositing nearly spherical pieces of extremely pure metal.

Characteristic of Metal Powders

The properties of metal powders have a direct impact on how well powder-metallurgical parts perform. Powder particle size, size distribution, form, purity, chemical content, flow characteristics, and particle microstructure are the most crucial properties of metal powders.

DISCUSSION

Powder Particle Size and Size distribution

By measuring the diameter of spherically shaped metal powder particles and the average diameter of non-spherically shaped particles using a sieve method or a microscope, the particle size of metal powder is quantified. The size range of metal powders used in powder metallurgy typically ranges from 20 to 200 microns. Particle size affects the compact's density/porosity, mold strength, permeability, mixing and flow properties, dimensional stability, and other factors. The amount of powder passing through 20 or 40 mesh sieves, or a sieve analysis, is used to define particle size distribution.

Particle Shape

Metal powders can be found in a number of morphologies, including spherical, sub-rounded, rounded, angular, sub-angular, and flakes. The packing and flow characteristics of powders are influenced by the form of the particles.

Chemical Composition

The kind and concentration of alloying elements and impurities are indicated by the chemical composition of metallic powder. The particle hardness and compressibility are typically determined by it. Chemical analysis techniques can be used to determine a powder's chemical makeup.

Particle microstructure

Internal porosity, different phases, and inclusions are shown by particle microstructure.

Apparent Density

The weight of a loosely heated amount of powder required to entirely fill a certain die cavity is referred to as apparent density.

Flow Characteristics

The ability of metal particles to flow is particularly crucial when swiftly filling molds. Metal powders that flow well fill a mold cavity consistently.

Mixing or Blending of Metal Powders

The initial step in creating powder metal parts is proper mixing or blending of the powders after the production of metallic powders. To create a homogenous mixture, the mixing is done either wet or dry with an effective mixer.

Compacting of Powder

The process of turning loose powder into a compact with precisely specified shape and size is known as compacting. This is done in a die on press machine at room temperature. It is possible for the compacting press to be mechanically or hydraulically driven. The die consists of a hollow in the required part's shape. Punches are used to apply pressure as metal powder is injected into the die cavity; they typically operate from the top and bottom of the die, as shown in Fig. 25.1. Although high-quality steel is typically used to make dies, large production runs occasionally call for the usage of carbide dies. Pressure should be exerted uniformly and simultaneously from above and below throughout the compacting process. The amount of pressure used should be sufficient to for the powder to cold weld. The green strength from cold welding binds the pieces together and makes them handleable[7]–[9]**.**

Sintering

In order to sinter materials that have been compacted, a furnace must be heated to a temperature below that of at least one of the principal ingredients while maintaining a regulated environment. The following variables affect the sintering temperature and duration:

1. Type of metal powder
2. Compressive load used
3. Strength requirements of the finished parts.

The metal components are gradually heated and soaked at the necessary temperature in the sintering furnace. Powders form cohesive bodies during this progressive heating process. Sintering causes the delicate green compacts created by pressing to become stronger. Additionally, it improves the powder metal parts' density, ductility, and electrical conductivity.

Secondary Operations

While some powder metal components can be used directly from the sintering process, in other instances, extra secondary procedures are required to provide the requisite surface polish, tight tolerance, etc. The following types of secondary operations are possible:

1. Annealing.
2. Repressing to achieve tighter dimensional control or more density.
3. Milling.
4. Gleaming.
5. Drawing, forging, or rolling.
6. Surface coatings to ward off corrosion.
7. In certain circumstances, infiltration is required to offer greater strength, hardness, and density than can be obtained with straight sintering.
8. The plating techniques used for wrought or cast metal parts are very different from those used for parts made of powdered metal. Before plating, porosity in pieces made of powdered metal must be removed. Regular plating methods can be applied after the porosity has been removed.

Advantages of Powder Metallurgy

1. Powder metallurgy methods are quiet and hygienic.
2. Any detailed or complex shape can be produced in an article.
3. For many applications, the dimensional accuracy and surface smoothness that may be obtained are substantially greater, thus machining can be removed.
4. Unlike casting, no material is wasted during press forming machining, and the procedure uses all of the raw materials.
5. Through this method, difficult-to-process materials like diamond can be transformed into functional parts and tools.
6. Achieving high production rates is simple.
7. This procedure eliminates the phase diagram restrictions that prevent the production of alloys of mutually insoluble elements in a liquid state, such as copper and lead, and allows for the simple processing and shaping of mixtures of such metal powders.
8. Many products, such sintered carbides and self-lubricating bearings, that cannot be produced using conventional techniques are made possible by this process.
9. The method makes it possible to effectively manage the purity, density, porosity, particle size, etc. of the parts made using this method.
10. This method results in highly pure and long-lasting components.
11. It makes it possible to produce pieces out of such alloys, which have weak casting abilities.
12. Since precise ratios of the constituent metal powders can be employed, composition consistency can be ensured.

13. The preparation and processing of powdered iron and nonferrous parts made in this manner demonstrate excellent qualities that can only be generated in this manner.
14. Minimal waste can be produced while making simple shaped pieces with a precision of 100 microns.
15. Porous parts that could not be created in any other way can be produced.
16. It is possible to make parts with a wide range of compositions and materials.
17. Compared to other fabrication procedures, structure and characteristics can be controlled more precisely.
18. Highly skilled or qualified labor is not necessary when processing powder metallurgy
19. This approach makes it simple to generate extremely hard cutting tool bits, which are impossible to make using other production techniques.
20. The resultant component shapes are extremely reproducible.
21. It is possible to control grain size, create a generally homogeneous structure, and get rid of structural flaws such cavities and blowholes.

Limitation of Powder Metallurgy

1. The process of powder metallurgy is not cost-effective for small-scale production.
2. The price of the tool and die for the powder metallurgical setup is fairly expensive.
3. Because heavy presses and pricey instruments are needed for compacting, the size of products is constrained when compared to casting.
4. Metal powders are costly and, in some situations, challenging to store without significant degradation.
5. Powder metallurgy cannot create intricate or complex shapes created by casting because metallic powders cannot flow as much as molten metal can.
6. Generally speaking, pieces created using powder metallurgy do not have as good of physical qualities as forged or cast components.
7. Occasionally, it could be challenging to find specific alloy powders.
8. The bottom of parts that were crushed from the top often have less density.
9. This method cannot result in a structure that is entirely deep.
10. The method is deemed inefficient for small-scale production.
11. Powdering brass, bronze, and a number of steels is not an easy task.

Applications of Powder Metallurgy

The production of refractory metals, the building blocks for heat-resistant materials and extremely hard cutting tools, has been made possible through the powder metallurgy technique. Porous self-lubricating bearings are yet another crucial and practical component of goods created from metal powder. In other words, powder metallurgy products are essential to current technology, and their range of uses is growing every year. Below is a list of several powder metal items.

1. Products with pores, such as filters and bearings.
2. Tungsten carbide, stones, hammers, rock drilling bits, gauges, wire drawing dies, wire guides, stamping and blanking tools, etc.
3. Wrought-iron powder is used to make a variety of machine parts. Using tungsten carbide and titanium carbide powders, cutting tools that are highly heat and wear resistant are produced.
4. Electric bulbs, radio valves, oscillator valves, X-ray tubes, and other devices use refractory parts such as filament, cathode, anode, control grids, and electric contact points constructed of tungsten, tantalum, and molybdenum.
5. Products with complex shapes that need a lot of machining when created using other methods, including gears and other toothed components.
6. Elements used in the assembly of automobile parts, such as clutch facings, welding rods, piston rings, rocker shaft brackets, crankshaft drive or camshaft sprocket, door mechanisms, connecting rods and brake linings, etc.
7. Products include non-porous bearings, electric motor brushes, and other items where it is desirable to combine the qualities of two metals or metals and non-metals.
8. Manufacturing metal bearings with pores that are afterwards lubricant-impregnated. Automobile parts and brushes are made from powders of copper and graphite.
9. Cermet's are metal and ceramic alloys that are joined using a method similar to that used to join metal powders. They blend in them the advantageous qualities of metal hardness and high ceramic refractoriness. They are created in two different ways: using oxides and using carbides.

CONCLUSION

Powder metallurgy is a highly beneficial and adaptable manufacturing method that makes it possible to produce metal products with distinctive qualities and intricate geometries. It is favored in many industries because it has a number of advantages over traditional metalworking processes.The capacity of powder metallurgy to create components with a near-net shape is one of its main advantages. Extensive machining is not necessary to produce complicated shapes and internal details when metal particles are compacted into molds and heated and compressed to high temperatures. By doing this, less material waste is produced, production efficiency is increased, and complicated geometries can be made that would be challenging or impossible to make in other ways. The capacity to customize the characteristics of the finished products is another benefit of powder metallurgy. Manufacturers can regulate properties like hardness, strength, density, and porosity by carefully choosing the metal powder composition, additives, and processing settings. Due to their adaptability, materials can be produced with specialized properties suited for a variety of applications, including those in the consumer goods, automotive, aerospace, and medical fields.

REFERENCES

[1] J. M. C. Azevedo, A. CabreraSerrenho, and J. M. Allwood, "Energy and material efficiency of steel powder metallurgy," *Powder Technol.*, 2018, doi: 10.1016/j.powtec.2018.01.009.

[2] Z. Z. Fang *et al.*, “Powder metallurgy of titanium–past, present, and future,” *International Materials Reviews*. 2018. doi: 10.1080/09506608.2017.1366003.

[3] P. Novák, “Advanced powder metallurgy technologies,” *Materials*. 2020. doi: 10.3390/ma13071742.

[4] A. E. Nassar and E. E. Nassar, “Properties of aluminum matrix Nano composites prepared by powder metallurgy processing,” *J. King Saud Univ. - Eng. Sci.*, 2017, doi: 10.1016/j.jksues.2015.11.001.

[5] J. M. Torralba, P. Alvaredo, and A. García-Junceda, “High-entropy alloys fabricated via powder metallurgy. A critical review,” *Powder Metallurgy*. 2019. doi: 10.1080/00325899.2019.1584454.

[6] B. ren Ke *et al.*, “Powder metallurgy of high-entropy alloys and related composites: A short review,” *International Journal of Minerals, Metallurgy and Materials*. 2021. doi: 10.1007/s12613-020-2221-y.

[7] L. Romero-Resendiz, P. Gómez-Sáez, A. Vicente-Escuder, and V. Amigó-Borrás, “Development of Ti–In alloys by powder metallurgy for application as dental biomaterial,” *J. Mater. Res. Technol.*, 2021, doi: 10.1016/j.jmrt.2021.02.014.

[8] B. Sadeghi and P. Cavaliere, “Progress of flake powder metallurgy research,” *Metals*. 2021. doi: 10.3390/met11060931.

[9] E. H. Lalana, “Permanent magnets and its production by powder metallurgy,” *Revista de Metalurgia*. 2018. doi: 10.3989/revmetalm.121.

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PROPERTIES AND TESTING OF METALS

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ABSTRACT

In many different industries, including manufacturing, aircraft, automotive, construction, and testing metals, is crucial. This summary gives a general overview of the characteristics that metals display and the testing techniques used. It emphasizes how important it is to comprehend and assess these characteristics in order to guarantee the dependability, safety, and performance of metal parts and structures. Metals are excellent for a wide range of applications due to their inherent characteristics. These characteristics include heat conductivity, electrical conductivity, corrosion resistance, and mechanical characteristics (such as strength, ductility, and hardness). For the purposes of material selection, design optimization, and quality control procedures, understanding these qualities is essential.

KEYWORDS: *Magnetic, Material, Metals, Properties, Strength, Temperature.*

INTRODUCTION

The key characteristics of an engineering material dictate its usefulness, which affects how it responds to stimuli and limitations, either statistically or qualitatively. The many qualities of engineering materials are listed below.

1. Physical properties
2. Chemical properties
3. Thermal properties
4. Electrical properties
5. Electronic properties
6. Mechanical properties
8. 7 Optical properties [1]–[3].

1. Physical properties

Density, color, size and shape (dimensions), specific gravity, porosity, luster, and other essential physical characteristics of metals are listed below. Some of them are classified as follows.

a. Density

Density is defined as mass per unit of volume. Its unit in the metric system is kg/mm3. Aluminum and magnesium are favored in aerospace and transportation applications due to their extremely low density.

b. Color

It has to do with how well light reflects off of metal surfaces.

c. Size and shape

Any metal's dimensions reveal the size and shape of the substance. Size is determined by factors like length, width, height, depth, curvature diameter, etc. Shape specifies a section's rectangular, square, circular, or other shape.

d. Specific gravity

Any metal's specific gravity is calculated as the difference between the mass of the metal in a given volume and the mass of the same volume of water at a particular temperature.

e. Porosity

If a substance has pores, it is referred to as porous or permeable.

2. Chemical properties

The majority of engineering materials suffer from chemical deterioration of the metal surface when they come into touch with other substances with which they can react, making the study of chemical characteristics of materials vital. Corrosion resistance, chemical composition, and acidity or alkalinity are a few examples of the metals' chemical characteristics. The progressive degradation of a material caused by a chemical reaction with its surroundings is known as corrosion.

3. Thermal properties

To understand how metal reacts to temperature changes, such as a drop or rise, the study of thermal characteristics is crucial. Thermal conductivity, thermal expansion, specific heat, melting point, and thermal diffusivity are a few examples of different thermal properties. The following list of significant properties is provided.

a. Melting point

The temperature at which a pure metal or compound transforms from a solid into a liquid is known as the melting point. The temperature at which a liquid and a solid are in equilibrium is known as that temperature. It can also be considered the boundary between the solid and liquid phases. The type of bonds between atoms and molecules determines the melting point. Because of this, materials with stronger bonding have higher melting points. The melting point and bonding strength of solids are ranked in decreasing order by covalent, ionic, metallic, and molecular kinds. Copper has a melting temperature of 1080°C, aluminum is 650°C, and mild steel has a melting point of 1500°C.

4. Electrical properties

Conductivity, temperature coefficient of resistance, dielectric strength, resistivity, and thermoelectricity are some of the different electrical properties of materials. These characteristics are listed as follows:

a. Conductivity

The capacity of a substance to easily transmit electric current through it is known as conductivity; a material that exhibits this property will make it simple for electricity to go through it.

b. Temperature coefficient of resistance

It is typically used to describe how resistivity changes as a function of temperature.

c. Dielectric strength

It refers to a material's high voltage insulation capacity. A substance with a high dielectric strength may endure high voltages across it for a prolonged period of time before conducting current.

d. Resistivity

A material's ability to resist the flow of electricity through it is one of its properties.

e. Thermoelectricity

The thermoelectric effect occurs when two metals with different properties are linked, and when this junction is heated, a tiny voltage (in the millivolt range) is generated. It serves as the thermocouple's foundation. The characteristics of metals are used to create thermo-couples.

DISCUSSION

Magnetic Properties

The spin of the electrons and their orbital motion around the atomic nuclei determine the magnetic characteristics of materials. The opposite spins in some atoms cancel each other out, but when there are too many electrons spinning in one direction, a magnetic field is created. Many substances only display magnetic properties when exposed to an external electro-magnetic field, with the exception of ferromagnetic substances, which can generate permanent magnets. Numerous aspects of the structure and behavior of matter are specified by the magnetic characteristics of materials. Magnetic hysteresis, coercive force, and absolute permeability are three different magnetic properties of the materials that are characterized as follows[4]–[6].

a. Magnetic Hysteresis

Hysteresis is the quality of a magnetic substance caused by energy being lost in it upon reversal of its magnetism, or it is the lagging of magnetization or induction flux density behind the magnetizing force. Magnetic hysteresis is the difference between the temperature at which a certain material becomes magnetic and the temperature at which it ceases to be ferromagnetic below the Curie temperature. The hysteresis phenomenon is present in almost all magnetic materials.

b. Coercive Force

It is referred to as the magnetizing force required to totally neutralize the magnetism in an electromagnet once the magnetizing force's value reaches zero**.**

c. Absolute Permeability

It is described as the proportion of a material's flux density to the magnetizing force that created that flux density. Materials that are di-magnetic have permeability that is less than one, while materials that are paramagnetic have permeability that is larger than one.

5. Optical Properties

Refractive index, absorptivity, absorption co-efficient, reflectivity, and transmissivity are the primary optical characteristics of engineering materials. An essential optical characteristic of metal is its refractive index, which is described as follows.

a. Refractive index

It is described as the difference between the speed of a material and the speed of light in a vacuum. It is also known as the sine of angle of incidence to sine of refraction ratio.

6. Mechanical Properties

The behavior of the material is investigated to determine its strength and durability under the influence of various kinds of forces. The design of tools, machineries, and buildings depends heavily on the mechanical properties of materials. The nature and behavior of the flaws that exist within the crystal or at the grain borders, as well as the crystal structure and its bonding forces, are all factors that affect how these properties behave. The ability of a substance to resist mechanical forces and load is determined by its mechanical properties, which are those of metals. Strength, stiffness, elasticity, plasticity, ductility, malleability, toughness, brittleness, hardness, formability, cast ability, and weld ability are among the metal's primary mechanical characteristics. Tensile tests and stress-strain diagrams are helpful in understanding these qualities. Below is an explanation of the few significant and practical mechanical properties.

a. Elasticity

The ability of a material to return to its original shape after deformation when external forces are eliminated is defined as this. The ability of a material to return to its initial position following deformation when the tension or load is removed is another name for it. It is also known as the material's tensile property.

b. Proportional limit

It is described as the highest stress at which a material may continue to exhibit fully uniform rates of strain and stress. Even though it is challenging to quantify, it can be used to construct precision instruments, springs, and other things.

c. Elastic limit

Many metals can be stressed only a little bit above their proportionate limit without permanently setting. Elastic limit is the maximum tension that a material can withstand without permanently setting. Beyond this point, the metal loses its ability to take on its previous shape and will permanently set.

d. Yield Point

Ductile metals, in particular, stop exhibiting resistance to tensile forces at a given stress. This indicates that the metals flow and a sizeable permanent set occurs without a discernible increase in load. The yield point is where this occurs. The yield stress is the stress at the specific yield point that certain metals, like mild steel, show.

e. Strength

A material's strength is determined by its capacity to withstand external forces without breaking down or yielding. Stress is the internal resistance a material provides to an applied force from the outside. Strength is the ability of a metal to support a weight and resist being destroyed by external forces. The amount of load a material can withstand increases with its strength. The capacity to sustain stress without failing is thus determined by this feature of the material. The type of loading has an impact on strength. Tensile, compressive, shearing, and torsional strengths can always be evaluated. The term "ultimate strength" refers to the highest stress that a material can bear before breaking down. The material's greatest strength in tension is determined by its tenacity[7]–[9].

f. Stiffness

It is described as a material's capacity to withstand deformation under stress. Stiffness or rigidity refers to a material's resistance to elastic deformation or bending. A material has a high degree of stiffness or rigidity if it deforms under load only slightly or hardly at all. For example, steel and aluminium suspended beams may both be strong enough to support the necessary load, but the aluminium beam will "sag" or deflect more. In other words, a steel beam is more rigid or stiff than an aluminium beam. The Young's modulus of elasticity (E) is used to determine a material's stiffness if it exhibits linear stress-strain behaviour under Hooks law. The Young's modulus value directly correlates with how stiff a material is. In terms of tensile and compressive stress, it is referred to as the "modulus of elasticity"; in terms of shear, the "modulus of rigidity," which is typically 40% of the Young's modulus for materials that are often employed; and in terms of volumetric distortion, the "bulk modulus**."**

g. Plasticity

The mechanical feature of a material known as plasticity is what keeps the persistent deformation caused by a load. This material's property is necessary for ornamental work, coin image stamping, and forging. The capacity or propensity of a substance to experience some level of permanent deformation without rupturing or failing. Only after the elastic range of the material has been exceeded does plastic deformation occur. Such a material's property is crucial for various hot or cold working processes, including forming, shaping, and extrusion. Clay, lead, and other materials are plastic at ambient temperature, while steel is plastic when heated to the forging temperature. In general, this feature rises as material temperatures rise.

h. Ductility

The ability of a material to be pulled into wire when a tensile load is applied is referred to as ductility. A ductile substance needs to be robust and plastic. As empirical measures of ductility, the words % elongation and percent reduction in area are frequently employed to quantify ductility. Materials that can stretch by more than 5% are referred to as ductile materials. In order of decreasing ductility, the ductile materials frequently utilized in engineering practice are mild steel, copper, aluminum, nickel, zinc, tin, and lead.

i. Malleability

The capacity of a material to flatten into thin sheets while being subjected to strong compressive stresses without cracking can be referred to as malleability. The ability to roll or smash materials into thin sheets is a specific instance of ductility. Plastic should be a malleable substance, but strength is not required. In order of decreasing malleability, common engineering materials include lead, soft steel, wrought iron, copper, and aluminum. Metals like steel, aluminum, copper, tin, and copper are known for being very malleable.

j. Hardness

The capacity of a metal to cut through another metal is how hard it is. Because of its hardness, a harder metal may always cut or make an impression on lesser metals. It is a very significant characteristic of metals and has many different interpretations. It encompasses a wide range of characteristics, including machinability, wear resistance, scratch resistance, and deformation resistance.

k. Brittleness

The reverse of ductility in a substance is called brittleness. It is the ability of a material to break with only minor irreversible distortion. Brittle materials are those that exhibit less than 5% elongation with loading behavior. When tensile loads are applied to brittle materials, they snap without exhibiting any logical elongation. Brittle materials include pottery, glass, cast iron, brass, and brass.

l. Creep

A metal component will experience creep when it is subjected to a high continuous stress at a high temperature for an extended period of time. This slow and permanent deformation manifests as a crack that may eventually lead to creep failure.

m. Formability

Metals have the quality of being easily formed into a variety of shapes and sizes. The crystal structure of the metal, the grain size of the metal under hot and cold working, and the presence of alloying elements in the parent metal are the several aspects that influence the formability. Small grain size metals are best for shallow forming, whereas large grain size metals are best for heavy forming. Formability is improved by hot working. Low carbon steel can be formed easily.

n. Cast ability

Cast ability is a quality of metal that refers to how easily it can be cast into various forms and sizes. Brass, aluminum, and cast iron all have good casting properties.

o. Weld ability

The capacity of two similar or dissimilar metals to fuse together efficiently with or without the use of pressure and with or without the use of filler metal is known as weld ability. In descending order, iron, steel, cast steels, and stainless steels are the metals with the best weld ability.

Recovery, recrystallization and grain growth

Plastic deformation, a significant phenomenon, happens when metal is subjected to hot working and cold working operations. The crystal lattice is distorted by the plastic deformation of metal. It produces a fibrous structure by disassembling the initial equi-axed grains and raising the metal's energy level. When compared to its undeformed state, deformed metal is in a non-equilibrium, thermodynamically unstable state. Therefore, even at room temperature, spontaneous processes that cause strain-hardened metal to become more stable take place. Recovery, recrystallization, and grain development are the three processes via which metal tries to reach equilibrium as its temperature rises.

a. Recovery

Due to the rise in amplitude of the atoms' thermal oscillation when a strain-hardened metal is heated to a low temperature, the elastic distortions of the crystal lattice are diminished. The strain-hardened metal's strength will decrease as a result of this heating, but the metal's ductility and elastic limit will increase. These properties, however, will not return to the initial values of the material prior to strain-hardening. The microstructure of metal has not changed during this time. Recovery is the partial restoration of the original properties brought about by decreasing the deformation of the crystal lattice without noticeably changing the microstructure. The rate of recovery is fastest at the initial stage and slows down over extended periods of time at a given temperature. Therefore, when temperature rises, more recuperation happens in a usable length of time. In a certain cold worked metal, each unique attribute recovers at a distinct rate and attains varying degrees of completion**.**

b. Recrystallization

Recrystallization is the process of forming new, equi- axed grains in metal after heating, as opposed to the orientated fibrous structure of the deformed metal. The first thing that happens when metal is heated is the formation of new, tiny grains. These grains quickly increase until they can no longer expand because one grain is touching another. The metal develops a new crystallized structure and loses its old system of grains in the process. In the metal, recrystallization results in new grains or crystals with the same structure but no new structures. It entails allowing the metal's atoms to break free from the bonds in the distorted lattice, forming the nucleus of equiaxed grains, and then allowing these grains to expand as atoms move from deformed to un-deformed crystallites. Finer grains get purified and take on a fiber-like form. Recrystallization temperature is the point at which new grains begin to form during crystallization. The temperature at which 50% of a cold-worked material will recrystallize in 60 minutes is known as the recrystallization temperature.

c. Grain growth

On recrystallization of metal, the grains are smaller and somewhat regular in shape. The grains in metal will grow if the temperature is high enough or if the temperature is allowed to exceed the minimum required for recrystallization and this growth of grain is the result of a tendency to return to more stable and larger state. It appears to depend primarily on the shape of the grain. For any temperature above the recrystallization temperature, normally there is practical maximum size at which the grains will reach equilibrium and cease to grow significantly. However, there are certain kinds of abnormal grains growth in metal that occur as a result of applied or residual gradients of strain due to non-uniform impurity distribution, and which permits growing very large single grain in metal[10], [11].

CONCLUSION

In many sectors, the characteristics and testing of metals are crucial factors. The examination and knowledge of metal properties allow for the best material choice and design, ensuring the performance and durability of metal parts and structures. In order to evaluate the mechanical, thermal, and chemical characteristics of metals, facilitate quality control, and guarantee the dependability and safety of metal products, testing methods are essential. The evaluation of metal properties must continue to improve in precision, efficacy, and cost-effectiveness as a means of spurring innovation and development across industries.

REFERENCES

[1] J. Slotwinski, A. Cooke, and S. Moylan, “Mechanical properties testing for metal parts made via additive manufacturing: A review of the state of the art of mechanical property testing,” in *Additive Manufacturing Materials: Standards, Testing and Applicability*, 2015.

[2] I. Ait-Mansour, N. Kretzschmar, S. Chekurov, M. Salmi, and J. Rech, “Design-dependent shrinkage compensation modeling and mechanical property targeting of metal FFF,” *Prog. Addit. Manuf.*, 2020, doi: 10.1007/s40964-020-00124-8.

[3] E. Zhang, X. Zhao, J. Hu, R. Wang, S. Fu, and G. Qin, “Antibacterial metals and alloys for potential biomedical implants,” *Bioactive Materials*. 2021. doi: 10.1016/j.bioactmat.2021.01.030.

[4] C. E. Pelin, G. M. Stoican, A. Stefan, M. V. Pricop, S. Ilina, and G. Pelin, “Mechanical properties of 3D printed metals,” *INCAS Bull.*, 2021, doi: 10.13111/2066-8201.2021.13.1.13.

[5] J. Xu, “Research on Physical Properties Testing Technology of Metal Materials,” *OA J. Chem. Mater.*, 2021, doi: 10.26855/oajcm.2021.07.001.

[6] R. Singh, *Applied Welding Engineering: Processes, Codes, and Standards, Third Edition*. 2020. doi: 10.1016/C2019-0-03490-5.

[7] R. Singh, “Mechanical Properties and Testing of Metals,” in *Applied Welding Engineering*, 2016. doi: 10.1016/b978-0-12-804176-5.00011-6.

[8] T. Xu, K. Wang, and S. Song, “Measurement uncertainty and representation of tensile mechanical properties in metals,” *Metals*. 2021. doi: 10.3390/met11111733.

[9] J. Butt and R. Bhaskar, “Investigating the effects of annealing on the mechanical properties of FFF-printed thermoplastics,” *J. Manuf. Mater. Process.*, 2020, doi: 10.3390/jmmp4020038.

[10] K. W. A.B. Spierings, M. Voegtlin, T. Bauer, “Materials Testing Standards for Additive Manufacturing of Polymer Materials :,” *Prog Addit Manuf*, 2015.

[11] A. Cooke and J. Slotwinski, “Properties of metal powders for additive manufacturing: A review of the state of the art of metal powder property testing,” in *Additive Manufacturing Materials: Standards, Testing and Applicability*, 2015.

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A BRIEF INTRODUCTION ON SHAPER, PLANER AND SLOTTER TECHNIQUES

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ABSTRACT

Basic machining techniques used in the manufacturing sector to form and smooth workpieces include shaping, planning, and slotting. These procedures have helped several industries, including the automotive, aerospace, and construction sectors, produce intricate components with high levels of precision. An overview of the ideas and uses of shapers, planers, and slotting is given in this abstract, emphasizing how crucial they are to contemporary production. Shapers are adaptable tools used to machine flat workpiece surfaces. They use a single-point cutting tool mounted on a reciprocating ram that cuts into the workpiece as it goes back and forth. Shapers are particularly good at creating dovetails, keyways, and straight edges. They are frequently used to form tiny to medium-sized components with complex profiles.

KEYWORDS: *Shaper, Tool, Ram, Cutting Stroke, Feed, Mechanism.*

INTRODUCTION

A shaper is a type of reciprocating machine tool in which the ram drives the cutting tool in a straight line back and forth. Figure 1 depicts the shaper's fundamental parts. Its main goal is to create flat surfaces. These surfaces could be sloped, vertical, or horizontal. The shaper can generally create any surface made up of straight lines. Figure2 illustrates the shaping operation's fundamental principles. Using a single point cutting tool akin to a lathe tool, a shaper is used to create flat (plane) surfaces[1]–[3].

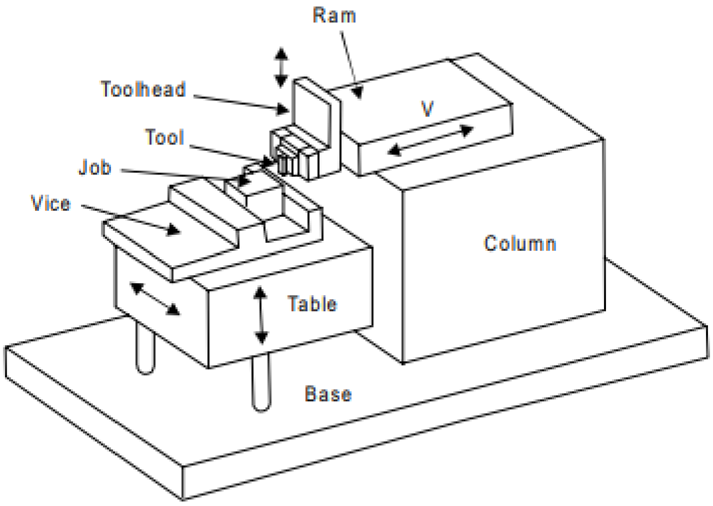

Figure 1: Shows principal components of shaper(wordpress.com).

Working Principle of Shaper

The tool holder, which is positioned on the ram, is used to hold a single point cutting tool. The workpiece is fastened directly on the table or held rigidly in a vice. The tables outside end may be supported. The cutting tool is held in a tool holder and travels across the workpiece when the ram reciprocates. In a typical shaper, the ram's forward stroke is when the material is cut. The rearward stroke is inactive and does not involve any cutting. By lowering the tool towards the workpiece, the feed is provided to the workpiece and the depth of cut is regulated.Figure 4 shows Cutting action and functioning of Clapper Box. Because of the quick return mechanism, the idle stroke takes less time than the cutting stroke in the forward direction.Figure 3 shows Job surfaces generated by shaper.

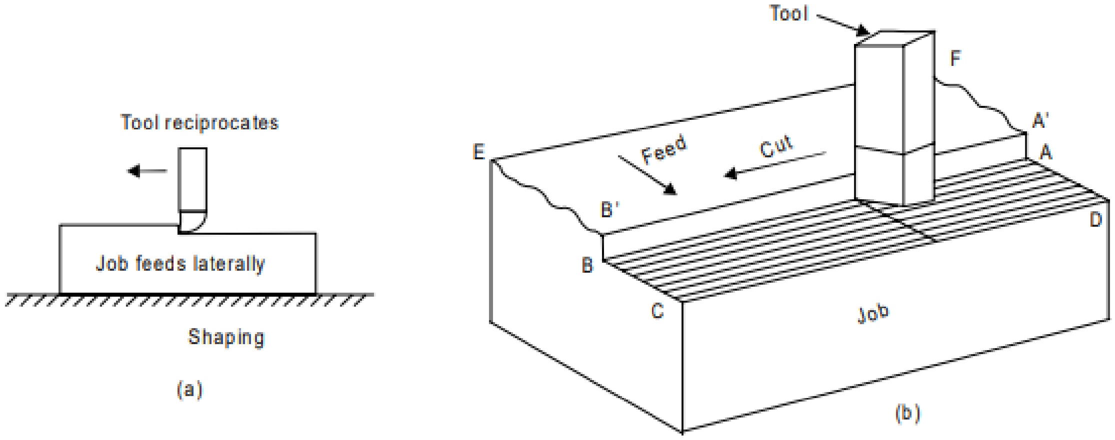

Figure 2: Shows working principle of shaping machine(wordpress.com)

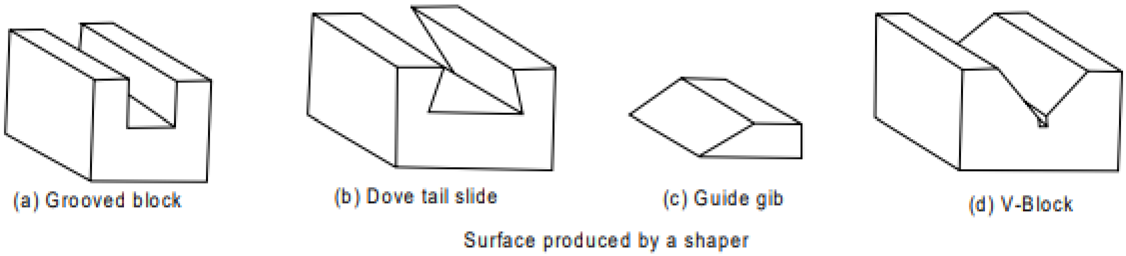

Figure 3: Shows Job surfaces generated by shaper(wordpress.com).

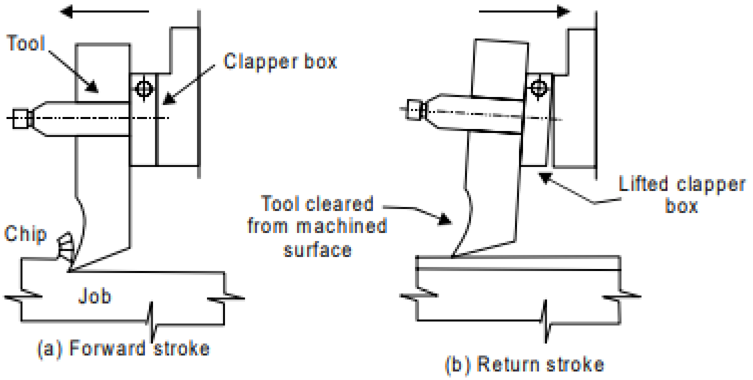

Figure 4: Shows Cutting action and functioning of Clapper Box(wordpress.com).

DISCUSSION

Types of Shapers

Shapers are classified under the following headings:

1. According to the type of mechanism used for giving reciprocating motion to the ram

(a) Crank type (b) Geared type (c) Hydraulic type

2. According to the type of design of the table:

(a) Standard shaper (b) Universal shaper

3. According to the position and travel of ram:

(a) Horizontal type (b) Vertical type (c) Traveling head type

4. According to the type of cutting stroke:

(a) Push type (b) Draw type.

1. Crank Shaper

The most typical kind of shaper is this one. It uses a crank mechanism to convert the machine's massive "bull gear" from a circular motion to a ram that is in reciprocating motion. If the shaper is belt-driven, either a single motor or an overhead line shaft powers the bull gear.

2. Geared Shaper

Geared shaper uses rack and pinion arrangement to obtain reciprocating motion of the ram. Presently this type of shaper is not very widely used.

3. Hydraulic Shaper

The ram's reciprocating motion is produced by hydraulic power in a hydraulic shaper. High pressure oil is pushed into the operational cylinder with a piston to generate hydraulic power. The piston rod connects the piston end to the ram. The piston is made to reciprocate by the high pressure oil, and the ram of the shaper receives this motion as well. The main benefit of this kind of shaper is that the ram drive's cutting speed and force remain consistent during the whole cut.

4. Standard Shaper

The table in a typical shaper can only move vertically and horizontally to provide the feed.

5. Universal Shaper

Most tool room work involves the use of a universal shaper. The table in this kind of shaper can be rotated around an axis parallel to the ram paths in addition to its horizontal and vertical movements, and its upper portion can be tilted about a second horizontal axis perpendicular to the first.

6. Horizontal Shaper

The ram carrying the tool reciprocates along a horizontal axis in this kind of shaper.

7. Vertical Shaper

The ram reciprocates along a vertical axis in a vertical shaper. These shapers are primarily utilized for internal surfaces, keyways, and slots or grooves.

8. Travelling Head Shaper

The ram in this kind of shaper reciprocates while moving across to provide the necessary feed.

9. Push Type Shaper

The metal is removed from the work when the ram pushes it away from the column, making it the most common form of shaper in use today.

10. Draw Type Shaper

When the ram goes towards the machine's column, or draws the work towards themachine, the metal is cut in this sort of shaper. The tool is configured in the opposite direction from a typical shaper.Figure 5 shows parts of a standard shaper.

Principal Parts of Shaper

The main parts are given as under.

1. Base
2. Column
3. Cross-rail
4. Saddle
5. Table
6. Ram
7. Tool head
8. Clapper box
9. Apron clamping bolt
10. Down feed hand wheel
11. Swivel base degree graduations
12. Position of stroke adjustment hand wheel
13. Ram block locking handle
14. Driving pulley
15. Feed disc
16. Pawl mechanism
17. Elevating screw

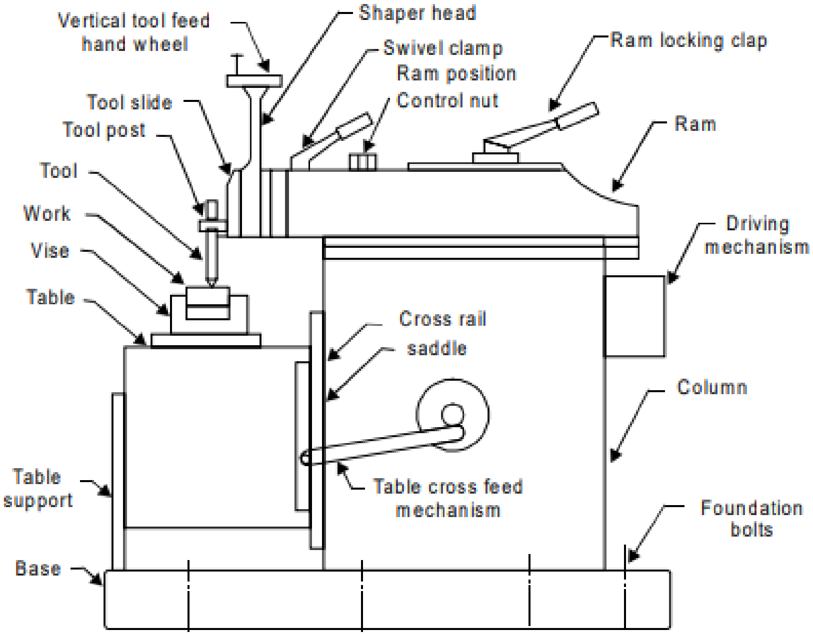

Figure 5: Shows parts of a standard shaper(wordpress.com).

1. Base

To prevent vibration, the cast iron body is solid and heavy and can support a significant compressive force. All other machine components are installed over it and are supported by it. Depending on the size of the machine, the base may be firmly attached to the shop floor or to a bench.

2. Column

A cast in the shape of a box that is mounted on the base is the column. It contains the ram-driving system. On the top of the column that the ram reciprocates, two precisely machined guide ways are offered.

3. Cross rail

On the top of the cross rail, which is perpendicular to the rai1 axis, are two parallel guiding ways. It is fixed to the column's front vertical guide ways. By turning an elevating screw, which moves the cross rail up and down on the vertical face of the column, the table may be raised and lowered to handle different-sized projects. Within the cross rail and parallel to the top guide ways of the cross rail, a horizontal cross feed screw is installed. The table is moved in a transverse direction by this screw[4]–[6].

4. Saddle

The table's top is supported by the saddle, which is mounted on the cross rail. The table moves obliquely as a result of the across movement of the saddle caused by the cross feed screw being rotated manually or mechanically.

5. Table

The table is a box-like casting with T-slots for clamping the work on the top and sides. It is bolted to the saddle and is moved vertically and crosswise by the cross rail and saddle.

6. Ram

It is the shaper's reciprocating portion, and it moves back and forth along the guideways set up above the column. The column's internal reciprocating mechanism is coupled to Ram.

7. Tool head

The tool head of a shaper serves the following purposes:

(1) It holds the tool firmly;

(2) It permits the tool to move vertically and angularly;

(3) It enables the tool to automatically release during the return stroke.

The apron clamping bolt, clapper box, tool post, down feed, screw micrometer dial, down feed screw, vertical slide, apron washer, apron swivel pin, and swivel base are the different components of the tool head of the shaper. While milling a vertical or angular surface, the vertical slide carrying the tool can move down feed or angularfeed by twisting the downfeed screw handle.

A micrometer dial on the top of the down feed screw can be used to change the feed rate or cut depth. A screw secures the apron, which is made up of a clapper box, clapper block, and tool post, to the vertical slide. The clapper block is housed between the two vertical walls on the apron known as the clapper box, and it is attached to it by a hinge pin. The clapper block is supported by the tool post. The clapper block and clapper box fit tightly together to form a strong tool support during the forward cutting stroke. The block is sufficiently lifted out of the clapper box on the return stroke by the tool's modest frictional drag on the work to prevent the cutting edge from dragging and resulting in wear. Additionally, the work surface is shielded from any dragging-related harm.

Specification of Shaper

A shaper's size is determined by the longest stroke or cut it is capable of making. Shaper sizes typically range from 175 to 900 mm. In addition to the stroke length, the complete specification of a shaper may also call for information on the type of drive (belt drive or individual motor drive), the amount of floor space needed, the weight of the machine, the ratio of cutting to return strokes, the number and amount of feed, the power input, etc.

Shaper Mechanism

In a shaper, a device installed inside the column or the machine converts the drive's rotating motion into the ram's reciprocating motion. In a conventional shaper, metal is removed during the forward cutting stroke whereas there is no metal removal during the return stroke. The shaper mechanism is made to drive the ram holding the tool at a relatively slower speed during the forward cutting stroke, but to let the ram to move at a quicker speed during the return stroke to shorten the idle return time. The rapid return mechanism is the name of this device. The quick return mechanism of the machine and the reciprocating movement of the ram are typically achieved using one of the following techniques:

(1) Crank and slotted link mechanism

(2) Whitworth quick return mechanism

(3) Hydraulic shaper mechanism

Crank and Slotted Link Mechanism

In a crank and slotted link mechanism the pinion transfers motion or power to the bull gear from an individual motor or overhead line shaft. A big gear installed inside the column is called a bull gear. By adjusting the gearing or by merely shifting the belt on the step cone pulley, the speed of the bull gear can be altered. The bull gear's center is connected to a radial slide.

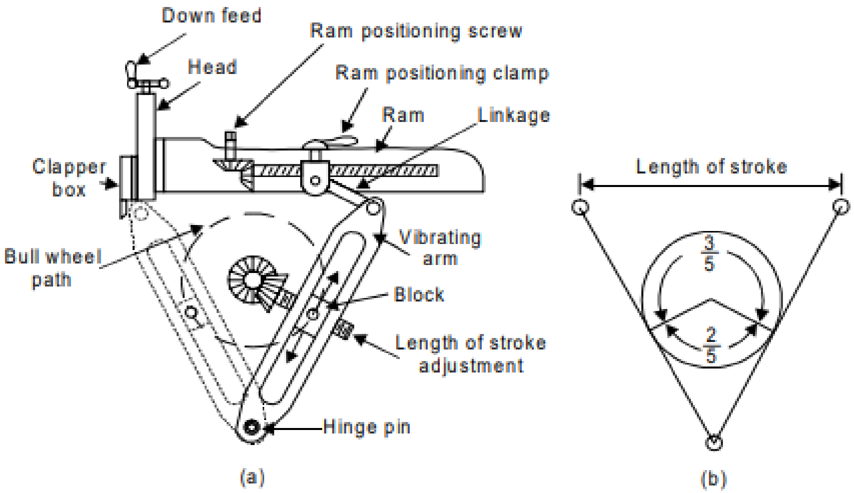

Figure 6: Shows Crank and Slotted Link Mechanism(wordpress.com).

The crank pin is installed into a sliding block that is carried by this radial slide. The bush pin will rotate at a constant pace as the bull gear rotates. The slotted link is fitted with a sliding block that is attached to the crank pin.Figure 6 shows Crank and Slotted Link Mechanism. The rocker arm is another name for this slotted link. It is joined to the column's frame by a pivot at its bottom end. A pin holds the forked upper end of the rocker arm to the ram block. Bull gear revolution causes the crank pin to move up and down the crank pin circle and rotate on the crank pin circle, giving the slotted link a rocking motion that is transmitted to the ram. Thus, the ram's reciprocating motion is created from the bull gear's rotating motion[7]–[9].

Planer

Similar to a shaper, a planer is typically used to create flat surfaces that are horizontal, vertical, or inclined using a single point cutting tool. However, it is used to machine huge, heavy workpieces that cannot fit on a shaper's table. The planer is typically used to manufacture numerous tiny items held in line on the platen in addition to major work. Open housing planers and double housing planers are the two basic types of planersWith the aid of the grooves on the planer's base, the larger work is fixed and precisely guided as it moves back and forth. The work piece is secured to the worktable and the cutting tools are held in the tool heads of the double housing planer. The worktable is supported by the gin tool heads, which can move side to side, or at a right angle to the worktable's motion.

On a horizontal cross rail that can be raised and lowered are tool heads placed. Cutting is accomplished by feeding the tool at right angles to the workpieces primary linear motion (motion X) using motions Y and Z. A rack and pinion drive with a variable speed motor typically handles the worktable's main motion. Similar to the shaper, the feed motion is intermittent, and the tool posts are mounted on clapper boxes to prevent interference between the tools and workpiece on the return stroke. The greatest solid that can reciprocate under the tool determines the size of a conventional planer. To fully design a planer, additional factors may be needed, such as table size (length and width), kind of drive, available speeds and feeds, power input, machine weight, necessary floor space, etc[10]–[12].

CONCLUSION

The manufacturing sector relies heavily on shapers, planers, and slots to produce accurate and complex components. In order to increase efficiency and precision, these machining techniques have changed over time, including cutting-edge technologies and automation. For engineers and manufacturers looking for effective and dependable methods for shaping and machining workpieces, understanding the concepts and uses of shapers, planers, and slotting is crucial.

REFERENCES

[1] W. J. Kaup,“Machine-shop Practice,” *Nature*, 1915, doi: 10.1038/095259b0.

[2] D. Arola and M. Ramula, “Machining-induced surface texture effects on the flexural properties of a graphite/epoxy laminate,” *Composites*, 1994, doi: 10.1016/0010-4361(94)90143-0.

[3] A. Singh, M. Asjad, P. Gupta, and J. Quamar, “An Approach to Develop Shaper Cum Slotter Mechanism: A Reconfigurable Machine Tool,” *South Asian J. Bus. Manag. Cases*, 2019, doi: 10.1177/2277977919833765.

[4] J. Tang and X. Yang, “Research on manufacturing method of planing for spur face-gear with 4-axis CNC planer,” *Int. J. Adv. Manuf. Technol.*, 2016, doi: 10.1007/s00170-015-7417-3.

[5] S. Ravindran, “Productivity improvement and energy conservation with modified tool heads of shaper and planer,” *Middle - East J. Sci. Res.*, 2012, doi: 10.5829/idosi.mejsr.2012.12.12.34.

[6] J. Kumabe, “Fundamental Research on the Ultrasonic Planer and Shaper,” *Trans. Japan Soc. Mech. Eng.*, 1960, doi: 10.1299/kikai1938.26.827.

[7] W. F. Walker, “The Machine Tool Laboratory — 5: Single□ Spindle Automatic Lathe Work,” *Education + Training*. 1962. doi: 10.1108/eb015103.

[8] R. Singh, “Mold and Core Making,” in *Introduction to Basic Manufacturing Process and Workshop Technology*, 2006.

[9] W. Wagner, “I. Planers, Shapers and Slotters,” in *Machine Tools (Metal Working - Wood Workings)*, 2019. doi: 10.1515/9783486738216-003.

[10] M. J. Martín, F. Martín, C. Bermudo, and L. Sevilla, “Teaching machines tools operation in virtual laboratories of engineering faculties,” 2014. doi: 10.1007/978-3-319-01836-2_18.

[11] S. Kaneko, H. Utsunomiya, Y. Saito, T. Sakai, and N. Furushiro, “Improvement of ridging behaviour of ferritic stainless steel by spread rolling method,” *Tetsu-To-Hagane/Journal Iron Steel Inst. Japan*, 2003, doi: 10.2355/tetsutohagane1955.89.6_653.

[12] H. Ota and K. Kono, “Chatter Vibrations Of Machine Tool Or Work With Directional Stiffness Inequality.,” *Bull JSME*, 1973, doi: 10.1299/jsme1958.16.942.

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EXPLANATION OF SHEET METAL WORK

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ABSTRACT

Thin metal sheets are formed into different components and structures through the fundamental manufacturing process known as sheet metal work. This abstract gives a brief introduction to sheet metal work, covering its applications, methods, equipment, and difficulties. It highlights the value of sheet metal work in sectors including automotive, aerospace, building, and electronics, where accuracy and effectiveness are essential. The abstract also focuses on improvements in sheet metal work, such as computer-aided design (CAD), laser cutting, and automated bending, which have greatly increased productivity and precision. This abstract provides an overview of the fascinating and important topic of sheet metal work.

KEYWORDS: *Cutting, Hammer, Sheet Metal, Stake, Steel, Work.*

INTRODUCTION

Automobile bodies, kitchenware, cabinets, appliances, electronics, electrical parts, aerospace parts, refrigeration and air conditioning parts, etc. are among the products created by the sheet metal processing process. Generally speaking, a plate with a thickness of less than 5 mm is referred to as sheet metal. Sheet metal products are more affordable and lighter than other materials. Work on sheet metal forming dates back to 5000 BC. Sheet metal parts have advantages of lightweight and adaptable shapes over casting and forging. Low carbon steel is most frequently used in sheet-metal processing activities due to its good strength and formability properties. Numerous components that were formerly created by casting or machining have now been replaced with metal stampings. A very small number of times, sheet metal products are used to replace castings or forgings. In engineering work, sheet metal work has its own significance. The trade of sheet metal processing is important in engineering projects because it helps us meet our daily needs. Sheet meta1s are used to create a wide range of items, including those that serve domestic necessities, decorative projects, and other engineering items. A quality product that has been appropriately created may result in time and money savings[1]–[3].

Further machining is not necessary when working with sheet metal, unlike with casting or forging. Working with sheet metal requires less time than machining, around half as much time. Knowing geometry, mensuration, and metal characteristics is crucial for working with sheet metal because practically all designs are created by modifying the surfaces of various geometrical shapes including cylinders, prisms, cones, and pyramids. In sheet metal work, a variety of operations are to be carried out on sheet metal using hand tools and press machines to create a product of the desired shape and dimension. These operations include shearing, blanking, piercing, trimming, shaving, notching, shaping, bending, stamping, coining, embossing, etc. Black iron, galvanized iron, stainless steel, copper, brass, zinc, aluminum, tin plate, and lead are the most common metals used in sheet metal work.

Metals used in Sheet Metal Work

In sheet metal work, the following metals are typically utilized:

1. Black Iron Sheet

It is most likely the least expensive metal utilized in sheet metal work. It has a blue black color and is typically utilized as uncoated sheets. It is simple to roll up to the required thickness. Being uncoated, it corrodes quickly. Therefore, it can be painted or enameled to lengthen its lifespan. Roofs, food containers, stove pipes, furnace fittings, dairy equipment, tanks, cans and pans, etc. are typically made of this metal**.**

2. Galvanized Iron

It is sometimes referred to as G.I. sheets. It is molten zinc covered soft steel. This coating enhances attractiveness and water resistance while preventing the growth of rust on the surface. GI sheets are used to make items like pans, furnaces, buckets, cabinets, etc.

3. Stainless Steel

It is a steel alloy containing nickel, chromium, and trace amounts of other elements. It is effectively resistant to corrosion. It costs more but is more durable than GI sheets. 1t is utilized in kitchenware, food processing equipment, food handling products, hospital surgical tools and instruments, chemical plant components, etc.Tin, lead, copper, aluminum, and other metals are also used to make sheet metal.

Sheet Metal Tools

The following tools are commonly used for sheet-metal work:

(i) Hand shears or snips
(ii) Hammers
(iii) Stakes and stake holder
(iv) Cutting tools
(v) Measuring tools

Hand shears or snips

They are used to cut thin, soft metal sheets that are 20 gauge or thinner and resemble a pair of scissors. The sheets must be sized and shaped by them. Both straight and circular cuts are possible. Figure 1 shows types of hand shear and snips.The following are some varieties of hand shears:

1. Straight hand shear

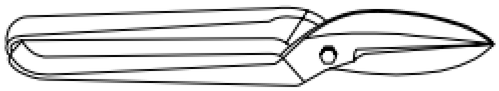
It is employed for general cutting tasks, straightening out cuts, and trimming away excess metal.

2. Universal shear

Its blades are made for universal straight line cutting as well as internal and external contour cutting. It is clearly distinguishable as a right- or left-handed kind because the top blade is either on the right or on the left.

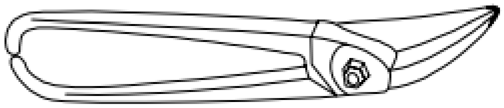
3. Curved hand shear

It is used to cut curved or circular objects between 20 and 35 cm in diameter.



Straight hand shear

Universal shear



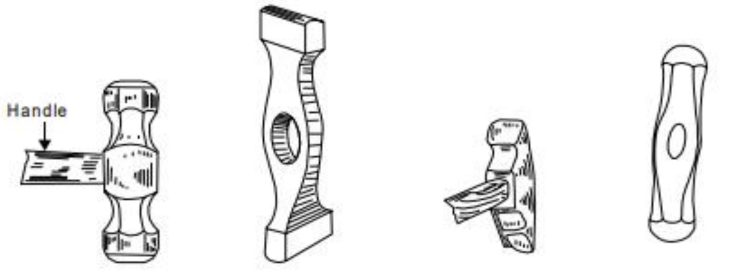
Curved hand shear

Figure 1: Shows Types of hand shear and snips(wordpress.com)

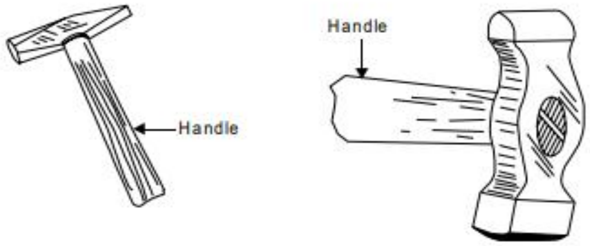
DISCUSSION

Hammers

The several types of hammers used in sheet metal work for creating shapes are shown in Figure 2. The following list includes the usage for several types of hammers.



(a) Smoothing hammer (b) Stretching hammer (c) Creasing hammer (d) Hollowing hammer



(e) Riveting hammer (f) Planishing hammer

Figure 2: Shows different types of hammers(wordpress.com)

(a) **Hammer for smoothing**. A sheet metal joint is levelled and smoothed using a smoothing hammer.

(b) **Hammer for stretching**. For extending sheets, a stretching hammer is utilized.

(c) **Creasing hammer**. The joint edges of a sheet metal item are closed down using a crazing hammer.

(d) **Hollowing hammer**. For hollowing sheet metal parts, use a hollowing hammer. It can also be used to create acute radii.

(e) **Rivetinghammer**. Forming riveted heads requires the employment of a riveting hammer

(f) **Planishing hammer**.For minor marks or indentations on the sheet metal job surface and to true the contour of the work, a planishinghammer. It makes the finished sheet metal work more supple

Stakes

Metal sheets are bent into a variety of forms using stakes. It functions as a kind of anvil to support the sheet when working with sheet metal. A shank with a head or horn make up this object. A tapered bench socket is intended to accommodate the stake's shank. The head or horn of the stake comes in a wide range of shapes and sizes. Stakes' working faces are machined or ground to the required form. These stakes are easily manufactured by bending, seaming, or shaping operations with the use of a hammer. Some stakes are constructed from forged mild steel and cast steel on the outside. The better class stakes, however, are constructed of either cast iron or cast steel[4]–[6].

1. Beak horn stake

Beak horns are primarily employed for shaping, riveting, and seaming sheet metal-based items. It is not quite as appropriate as a blow horn stake. It has a rectangular-shaped horn at one end and a thick, tapering horn at the other.

2. Funnel stake

Planishing tapering work and hand shaping of funnels and other similar conical shapes out of sheet metal frequently involve the employment of a funnel stake.

3. Half moon stake

Half moon stakes are primarily utilized for throwing up curved sheet metal work edges and for the initial phases of wiring curved edges.

4. Round bottom stake

It is typical practice to square up edges and put up the bottom of cylindrical jobs constructed of sheets using a round bottom stake.

5. Bick Iron

It is typically employed to produce taper handles, spouts, and other tubular work. When working with rectangles, bick iron's narrow flat anvil end is quite helpful.

6. Hatchet stake

The hatchet stakeis typically used for manually shaping sheet metal into pans and boxes with sharp bends and corners. This stake has a beveled straight edge that is sharp on one side.

7. Creasing with horn stake

The round horn of the creasing horn stake is used to create sheets of conical-shaped pieces. The opposite end has a square horn that tapers and contains spaces for wire and beading.

8. Needle case stake

Typically, a needle case stake is used to bend sheets. It has a spherical, thin horn that can be used to create wire rings and tubes.

9. Candle mold stake

When shaping, seaming, and riveting long flaring products made of sheet metal, the candle mould stake has two horns for different tapers.

10. Blow horn stake

In general, tapering products like funnels are formed, riveted, and seamed using blow horn stakes.

11. Conductor stake

A conductor stake with two cylindrical horns of varying sizes. Small pipes and tubes of all sizes can be formed, riveted, and seamed using this method.

12. Double seaming stake

Two cylindrical horns of different sizes make up a double seaming stake which is frequently employed for riveting forms as well as seaming tubes and tiny pipes. Figure 3 shows different types of stakes.

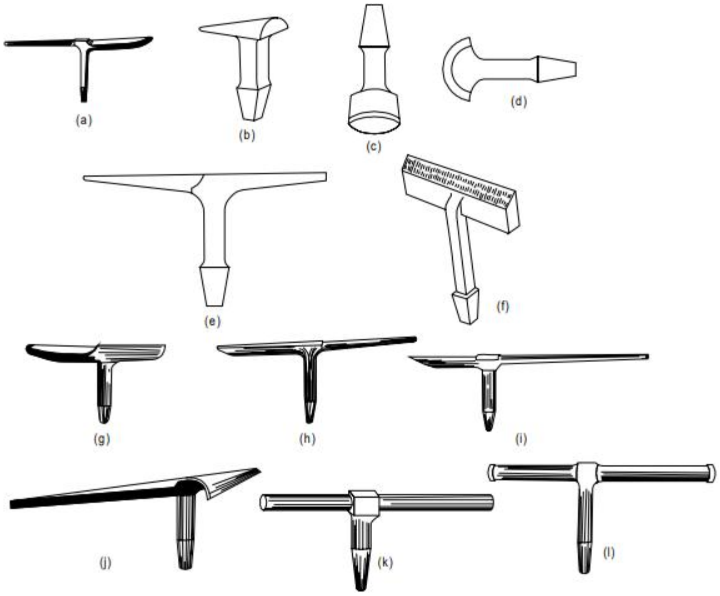


Figure 3:Shows different types of stakes(wordpress.com)

Cutting tool

Cutting tools are used in sheet metal shops; they are thoroughly discussed in work section along with pertinent data. Different varieties of files, chisels, scrapers, and hacksaws are often used cutting tools. Here are some of the most popular cutting instruments discussed[7]–[9].

1. **Files**. These include mill, flat, square, round, triangular, knife, pillar, and circular shapes.

2. **Hammers**. In sheet metal work, the flat and round nose chisels are most frequently employed.

3. **Scrapers**. These come in flat, triangular, half-round, and hook shapes.

3. **Hackshaws**. A power or hand hacksaw may be used in a sheet metal shop.Figure 4 shows stake holder

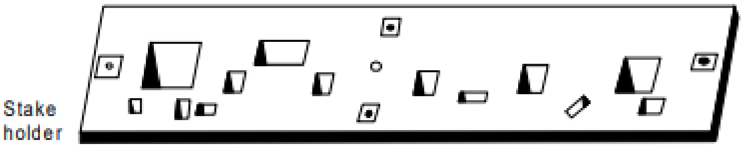


Figure 4: Shows stake holder(wordpress.com)

Measuring Tools

The list of the most popular measuring instruments is provided below.

1. Folding principle
2. Circumference rule.
3. Steel Rule
4. Vernier caliper
5. Micrometer
5. Thickness gauge

Measuring and Marking

Metal sheets come in a variety of typical sizes that are quite substantial. However, the needed sheet size for creating a component could be smaller, necessitating the cutting of a normal size sheet into multiple smaller pieces. Each piece must be enough to create one such component of the required size. The larger metal sheet is first marked with smaller sizes of the sheet metal section, and then the latter is cut into smaller pieces along the defined lines. Always add a small amount of cutting room to the needed overall sizes. A steel rule, a straight edge, a steel square, and a scriber are used to mark the bigger sheet with the overall dimensions of the required smaller sizes. In order for the scribed lines to be clearly visible, the sheet surface may need to be painted with coloring material. If circular pieces are required, they can be marked with a separator or trammel

CONCLUSION

Sheet metal work is an essential step in contemporary manufacturing since it enables the creation of sophisticated and precise components from thin metal sheets. Sheet metal work's adaptability is employed in a variety of industries, including the automotive, aerospace, building, and electronics, to create a variety of products, including enclosures, brackets, panels, and structural elements.Cutting, bending, shaping, and joining are just a few of the several sheet metal fabrication methods that need for expert expertise and specialized equipment. The field of sheet metal work has undergone a revolution as a result of technological developments over time. Software for computer-aided design (CAD) has improved the accuracy and effectiveness of product design and prototyping. Precision and detailed cuts on diverse metal sheets are now possible thanks to laser cutting technology, resulting in less material waste and more productivity. Automated bending equipment has increased bending processes' precision and consistency, resulting in high-quality final products.

REFERENCES

[1] S. Kashid and S. Kumar, “Applications of Artificial Neural Network to Sheet Metal Work - A Review,” *Am. J. Intell. Syst.*, 2013, doi: 10.5923/j.ajis.20120207.03.

[2] S. Kumar and R. Singh, “Automation of strip-layout design for sheet metal work on progressive die,” *J. Mater. Process. Technol.*, 2008, doi: 10.1016/j.jmatprotec.2007.04.119.

[3] Y. Abe, K. ichiro Mori, T. Maeno, S. Ishihara, and Y. Kato, “Improvement of sheet metal formability by local work-hardening with punch indentation,” *Prod. Eng.*, 2019, doi:

10.1007/s11740-019-00910-6.

[4] G. H. West, J. Dawson, C. Teitelbaum, R. Novello, K. Hunting, and L. S. Welch, “An analysis of permanent work disability among construction sheet metal workers,” *Am. J. Ind. Med.*, 2016, doi: 10.1002/ajim.22545.

[5] S. Ramakrishnan, B. Thamotharan, B. Niranjana, and J. Saranya, “Application of image processing for the quality testing of sheet metal work,” *Res. J. Appl. Sci. Eng. Technol.*, 2013, doi: 10.19026/rjaset.5.5095.

[6] A. M. Dale, K. Miller, B. T. Gardner, C. T. Hwang, B. Evanoff, and L. Welch, “Observed use of voluntary controls to reduce physical exposures among sheet metal workers of the mechanical trade,” *Appl. Ergon.*, 2016, doi: 10.1016/j.apergo.2015.06.026.

[7] T. B. Gonoring, L. P. Moreira, and M. T. D. A. Orlando, “An equivalent work-hardening description of an interstitial-free steel sheet based on uniaxial tensile and hydraulic bulge tests,” *J. Mater. Res. Technol.*, 2021, doi: 10.1016/j.jmrt.2021.05.097.

[8] M. H. Parsa and S. N. Al Ahkami, “Bending of work hardening sheet metals subjected to tension,” *Int. J. Mater. Form.*, 2008, doi: 10.1007/s12289-008-0019-y.

[9] A. Y. C. Nee, “An Overview of Applications of Artificial Intelligence (AI) in Sheet Metal Work,” in *Topics in Mining, Metallurgy and Materials Engineering*, 2017. doi: 10.1007/978-981-10-2251-7_1.

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A STUDY ON TYPES OF WELDING PROCESSES

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ABSTRACT

In many sectors, putting metals and alloys together to produce sturdy structures involves the welding process. An overview of the main features of welding, including its varieties, uses, difficulties, and advancements, is given in this abstract. It emphasizes the importance of welding in the manufacturing, building, and repair processes and emphasizes how important it is for developing and sustaining vital infrastructure. The abstract also mentions how weld efficiency and quality have increased as a result of developments in welding technologies like automation and robotics. Overall, this abstract introduces the extensive study of welding and clarifies its significance and effects on the industrial sector.

KEYWORDS: *Acetylene, Gas, Metal,Position, Pressure,Welding.*

INTRODUCTION

By fusion, two metals that are similar or dissimilar are joined by welding. With or without the application of pressure and with or without the use of filler metal, it unites various metals and alloys. Heat is used to cause the fusing of metal. Heat can be produced by chemical reactions, electric arcs, electric resistance, or gas combustion. Although pressure is sometimes used during welding operations, it is not a necessary component for all welding procedures. Although welding creates a permanent bond, the metallurgy of the component is typically changed. Therefore, for the majority of the crucial components, post-weld heat treatment is typically used. In several sectors, welding is utilized as a method of fabrication and repair. The construction of ships, pressure vessels, automotive bodies, off-shore platforms, bridges, welded pipes, sealing of nuclear fuel and explosives, etc. are some examples of typical applications for welding[1]–[3].

Most metals and alloys can be welded using one or more types of welding processes. But some materials are simpler to weld than others. Weld ability, a phrase used to describe how simple welding is, is frequently employed. A metal's weld ability is a quality that indicates how easily it may be joined to other metals, whether they are comparable or dissimilar.

A material's capacity to be welded depends on a number of variables, including the metallurgical changes brought on by welding, changes in hardness at and near the weld, gas evolution and absorption, the degree of oxidation, and the joint's propensity to split. Among metals, plain low carbon steel (C-0.12%) has the best weld ability. The materials with high cast ability are typically found to have l.Figure 1 shows Terminological Elements of Welding Process.

Edge Preparations

Metal joining surfaces' edges must first be prepped for welding. For welding butt joints, there are a variety of edge preparations that can be used, as shown in Figure 2.

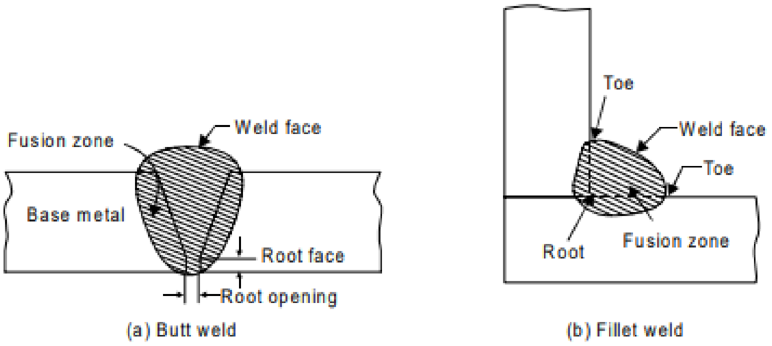

Figure 1: Shows Terminological Elements of Welding Process (wordpress.com).

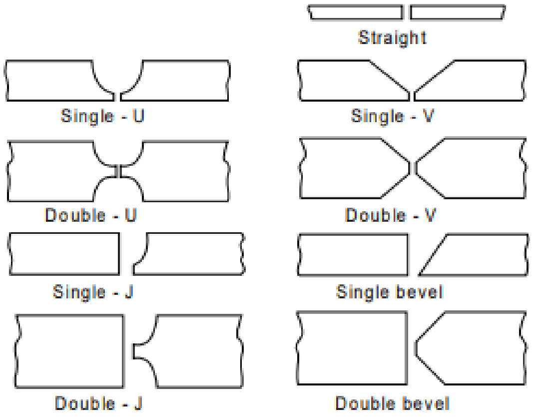

Figure 2: Shows Butt Welding Joints Edge Preparations (wordpress.com).

Welding Joints

In Figure 3, a few typical welding joints are displayed. Lap joints and butt joints are the two main types of welding joints. The primary types are shown below.

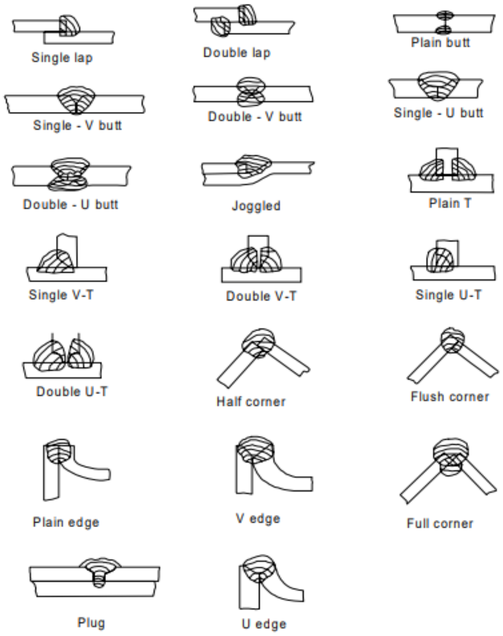

Figure 3: Shows Welding Joints(wordpress.com).

Lap Weld Joint

Single-Lap Joint

The majority of work is not advised for this joint, which is created by overlapping the edges of the plate. The single lap bends with relatively little resistance. For attaching two cylinders that fit within one another, it can be used satisfactorily.

Double-Lap Joint

Despite being stronger than a single-lap joint, this has the drawback of requiring twice as much welding.

Tea Fillet Weld

Although common, this style of joint shouldn't be used if a different design is available.

Butt Weld Joint

Single-V Butt Joint

Up to 15.8 mm thick plates can be used with it. The technology being employed determines the angle of the V, with the plates being placed at a distance of about 3.2 mm.

Double-V Butt Joint

When welding can be done on both sides of the plate, it is employed for plates thicker than 13 mm. Depending on the technique employed, the top V angle ranges from 60° to 80°, while the bottom V angle is 80.Figure 4 shows Kind of Welding Positions.

Welding Positions

There are four different categories of welding positions, as follows:

1. Flat or down hand position
2. Horizontal position
3. Vertical position
4. Overhead position

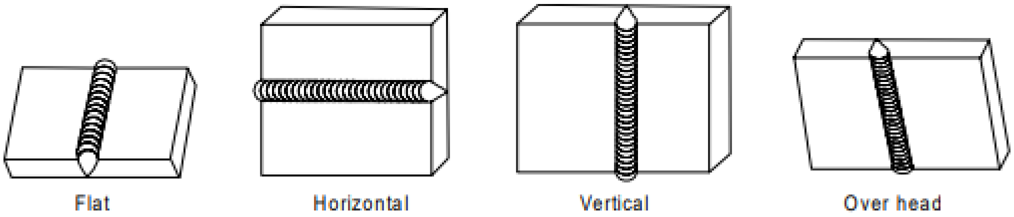

Figure 4: Shows Kind of Welding Positions(wordpress.com)

Flat or Downward Welding Position

The welding is done from the upper side of the joint in the flat position, also known as the down hand position, and the weld face is about horizontal. The easiest and most practical position for welding is this one. With this method, it is possible to produce quality welded joints quickly and with little chance of the welders becoming fatigued.

Horizontal Welding Position

The workpieces plane is vertical and the deposited weld head is horizontal when the joint is in the horizontal position. The rate of metal deposition during horizontal welding is comparable to that accomplished during flat or downhanded welding. The most frequent application of this welding position is in welding reservoirs and vessels.

Vertical Welding Position

When the workpiece is in the vertical position, the weld is deposited on a vertical surface, and the workpieces plane is vertical. Due to the effect of gravity on the molten metal at this position, it is challenging to produce satisfactory welds. Metal cannot run or drop from the weld, thus the welder must continually regulate it. There are two forms of vertical welding: vertical-up and vertical-down. Welding from the top down is ideal when strength is the main factor. For sheet metal welding and sealing operations, vertical-down welding is used.

Overhead Welding Position

Even more challenging to weld than the vertical position is the above position. Gravity is pulling against the molten metal much more strongly in this situation. The flame's pressure against the weld works to resist gravity's pull. When held overhead, the workpieces plane is horizontal. However, the welding is done from the bottom up. The welding end of the electrode is kept in an upright position. For overhead welding, it is recommended to utilize a relatively short arc and simple coated electrodes[4]–[6].

DISCUSSION

Advantages and Disadvantages of Welding

Advantages

1. Welding is a considerably faster and more cost-effective technique than other operations (such as riveting, bolting, casting, etc.).
2. If correctly regulated, welding produces permanent joints with strength comparable to or occasionally greater than base metal.
3. Welding can be used to unite a variety of metals and alloys, both similar and dissimilar.
4. Cheap general welding equipment is available.
5. It is simple to get portable welding equipment.
6. Design freedom is very broad with welding.
7. Welding jobs can be joined end-to-end, through spots, as continuous pressure-tight seams, or in a variety of other ways.
8. Machines can perform welding.

Disadvantages

1. The workpieces are subjected to residual stresses and distortion.
2. The welded joint requires heat treatment and stress relief.
3. Welding emits dangerous light radiation, gases, and splatter.
4. Fixtures and jigs may also be required to hold and position the welding components.
5. Prior to welding, the welding works must have their edges prepared.
6. Good welding can only be produced by skilled welders.
7. Due to the welded joint's different structure from the parent metal, heat during welding causes metallurgical changes.

Classification of Welding and Allied Processes

Today's industries use a variety of welding, brazing, and soldering techniques. The classification of welding and related operations can take many different forms. They could be categorized, for instance, according to the type of heat source blacksmith fire, flame, arc, etc. and the type of interaction liquid/liquid (fusion welding) or solid/solid (solid state welding) used to generate the heat. Additionally, there are two subcategories of welding processes: plastic (forge) and fusion. The general classification of welding and related processes is provided as follows, though[7]–[9].

1. **Welding Processes**

A. Oxy-Fuel Gas Welding Processes

a. Air-acetylene welding

b. Oxy-acetylene welding

c. Oxy-hydrogen welding

d. Pressure gas welding

B. Arc Welding Processes

a. Carbon Arc Welding

b. Shielded Metal Arc Welding

c. Submerged Arc Welding

d. Gas Tungsten Arc Welding

e. Gas Metal Arc Welding

f. Plasma Arc Welding

g. Atomic Hydrogen Welding

h. Electro slag welding

i. Stud Arc Welding

j .Electro-gas Welding

C. Resistance Welding

a. Spot Welding

b. Seam Welding

c. Projection Welding

d. Resistance Butt Welding

e. Flash Butt Welding

f. Percussion Welding

g. High Frequency Resistance Welding

h. High Frequency Induction Welding

D. Solid-state Welding Process

a. Forge Welding

b. Cold Pressure Welding

c. Friction Welding

d. Explosive

e. Diffusion

f. Cold Pressure Welding
g. Thermo-compression Welding
E. Thermit Welding Process
a. Thermit Welding
b. Pressure Thermit Welding
F. Radiant Energy Welding Process
a. Laser Welding
b. Electron Beam Welding

2. Allied Processes

A. Metal joining process or Metal Depositing Processes
a. Soldering
b. Brazing
c. Braze Welding
d. Adhesive Bonding
e. Metal Spraying
f. Surfacing
B. Thermal Cutting Process
a. Gas Cutting
b. Arc Cutting

Gas Welding

Gas welding is a form of fusion welding that binds metals by using the heat produced by the combustion of an oxygen/air and fuel gas mixture (such as acetylene, hydrogen propane or butane). The resultant extreme heat (flame) melts and bonds the edges of the pieces that need to be welded, usually with a filler metal added. Figure 5 depicts the gas welding process in action. Acetylene is the fuel gas that is typically utilised, but other gases can be used as well with a lower flame temperature. Of all the flames created by mixing oxygen and other fuel gases, the oxygen-acetylene flame is the most adaptable and intense. For some welding and brazing applications, other gases, such as hydrogen, propane, butane, natural gas, etc., may be employed

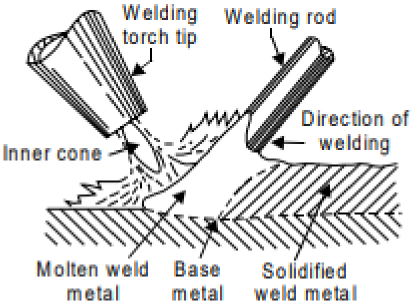

Figure 5: Shows Gas Welding Process(wordpress.com)

Oxy-Acetylene Welding

Acetylene and oxygen are properly diluted in the welding torch before being fired in this procedure. The flame that forms at the torch's tip is hot enough to melt and fuse the parent metal. Since the oxy-acetylene flame can melt the majority of commonly used ferrous and non-ferrous metals, it reaches a temperature of roughly 3300 °C. Typically, a welding rod or filler metal rod is inserted to the molten metal pool to slightly thicken the seam for increased strength.

Gas Welding

In compressed gas cylinders, acetylene and oxygen gas is kept. These gas cylinders vary greatly in size, style, and color. However, the size of these cylinders is typically 6 to 7 m3, and they are typically colored maroon for acetylene and black for oxygen, respectively. A substance that absorbs energy is placed inside of an acetylene cylinder and is saturated with the chemical solvent acetone. Acetone has the capacity to absorb huge amounts of acetylene and then release it as pressure is reduced. When producing acetylene gas on-site with the aid of acetylene gas generators, it is much more cost-effective to consume huge volumes of the gas. The carbide-to-water process is used to produce acetylene gas. Typically, oxygen gas cylinders hold around 40 liters of the gas at a temperature of 21°C and a pressure of about 154 Kgf/cm2. Every valve is equipped with a safety system that releases the oxygen before there is any risk of the cylinders rupturing in order to protect against dangerously high pressure, which may happen if the cylinders were exposed to fire. In the event of danger, the cylinder valves typically have fragile discs and fusible plugs[10].

CONCLUSION

In many sectors, connecting metals and alloys through welding is a necessary technique that produces durable structures and components. Arc welding, gas welding, and resistance welding are just a few of the several welding processes that can be used for a variety of applications and materials. Manufacturing, building, and repair all rely heavily on welding, which helps the global development and upkeep of essential infrastructure.While there are many benefits to welding, there are also issues that must be resolved. The quality and integrity of welded joints can be impacted by problems such weld imperfections, distortion, and residual stresses. However, many of these issues have been resolved because to developments in welding technology. Welding operations have been transformed by automation and robotics, raising precision, speed, and uniformity while lowering human error and strengthening worker safety.

REFERENCES

[1] D. G. Mohan and C. S. Wu, "A Review on Friction Stir Welding of Steels," *Chinese Journal of Mechanical Engineering (English Edition)*. 2021. doi: 10.1186/s10033-021-00655-3.

[2] H. Wang and Y. Wang, "High-velocity impact welding process: A review," *Metals*. 2019. doi: 10.3390/met9020144.

[3] M. M. El-Sayed, A. Y. Shash, M. Abd-Rabou, and M. G. ElSherbiny, "Welding and processing of metallic materials by using friction stir technique: A review," *Journal of Advanced Joining Processes*. 2021. doi: 10.1016/j.jajp.2021.100059.

[4] B. Wang, S. J. Hu, L. Sun, and T. Freiheit, "Intelligent welding system technologies: State-of-the-art review and perspectives," *Journal of Manufacturing Systems*. 2020. doi: 10.1016/j.jmsy.2020.06.020.

[5] Y. Zhang *et al.*, "Research and development of welding methods and welding mechanism of high-entropy alloys: A review," *Materials Today Communications*. 2021. doi: 10.1016/j.mtcomm.2021.102503.

[6] Y. Li, B. Yu, B. Wang, T. H. Lee, and M. Banu, "Online quality inspection of ultrasonic composite welding by combining artificial intelligence technologies with welding process signatures," *Mater. Des.*, 2020, doi: 10.1016/j.matdes.2020.108912.

[7] D. G. Mohan *et al.*, "Ac ce pte d M us pt," *Mater. Today Proc.*, 2019, doi: 10.1080/14484846.2018.1432089.

[8] H. Arora, R. Singh, and G. S. Brar, "Thermal and structural modelling of arc welding processes: A literature review," *Meas. Control (United Kingdom)*, 2019, doi: 10.1177/0020294019857747.

[9] S. H. Iftikhar, A. H. I. Mourad, J. Sheikh-Ahmad, F. Almaskari, and S. Vincent, "A comprehensive review on optimal welding conditions for friction stir welding of thermoplastic polymers and their composites," *Polymers*. 2021. doi: 10.3390/polym13081208.

[10] E. Karayel and Y. Bozkurt, "Additive manufacturing method and different welding applications," *Journal of Materials Research and Technology*. 2020. doi: 10.1016/j.jmrt.2020.08.039.

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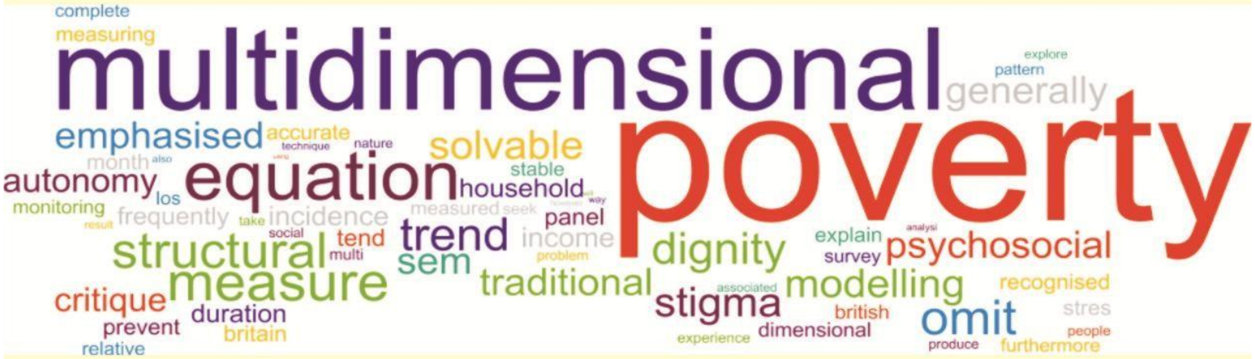

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