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SILICON AS AN ALLOYING ELEMENT IN STEELS

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ABSTRACT

Silicon is one of the most common in nature and ranks second after oxygen (26% Si in the earth's crust). Due to its high chemical affinity for oxygen and high availability, silicon is primarily used as a deoxidizer in steel production. In addition, silicon is introduced into the metal for its alloying.The article analyses the effect of the Silicon element on iron carbon alloys as analloying element.

KEYWORDS: *Silicon, Carbon, Iron, Slag, Alloy, Temperature, Feo, Deoxidation.*

INTRODUCTION

Silicon is a nonmetal, but under different conditions it can exhibit both acidic and basic properties. It is a typical semiconductor and is extremely widely used in electrical engineering. Its physical and chemical properties are largely determined by the allotropic state. Most often they deal with a crystalline form, since its qualities are more in demand in the national economy. Silicon has the following physicochemical properties: atomic mass 28.06; density 2.4 g / cm3; melting point 1414 ° C; boiling point 2287 ° C; melting heat 39.76 kJ / mol. Silicon has unlimited solubility in liquid iron, limited solubility in solid iron (up to 14%). With iron, silicon forms several compounds — Fe_3Si_2, FeSi and $FeSi_5$, but in liquid iron, only FeSi silicide (33.3% Si) is stable, having a melting point of 1410 ° C [1]. The oxygen compound of silicon, stable in steelmaking baths, is SiO_2 (melting point 1710 ° C).

MATERIALS AND ANALYSIS

For deoxidation, silicon is introduced into calm steel usually in an amount of 0.15—0.35%, into semi—calm steel - up to 0.10—0.12%. In boiling steel, silicon is an undesirable impurity that worsens the boiling of the metal in the mold and the structure of the ingot, therefore, the silicon content in boiling steel should not exceed 0.02—0.03%.

Silicon as an alloying element in steels is contained in an amount of 0.5—0.6% or more. Silicon-alloyed steel has higher values of yield strength, elasticity, impact resistance, small residual magnetism, good permeability, heat resistance, the ability to maintain hardness at relatively high temperatures in the quenched state, and other useful properties. Silicon is alloyed with steels for various purposes: structural (0.8—1.5% Si), tool (1.2—1.6% Si); spring-spring (1.3—2.0% Si), heat- and scale—resistant (2.0-3.0% Si), dynamic transformer (2.5—4.5% Si), etc. Usually steel is alloyed with silicon in combination with other impurities, most often in combination with chromium and manganese [2-3]. The silicon contained in the metal charge, although it is oxidized and lost almost completely during melting, but it usually has a positive effect on the course of the process. This is reflected in the improvement of the thermal balance of melting, since among the usual impurities of the metal charge, silicon is oxidized with the release of the greatest amount of heat.

In any steelmaking slag, silica is one of the most important components. The silica resulting from the oxidation of silicon in the bath is more active than the one introduced in the finished form and accelerates the process of slag formation. However, silica formed during the oxidation of silicon metal has a destructive effect on the main lining, especially in processe with high consumption of liquid cast iron, for example in converter. In addition, with a very high silicon content, a large amount of slag is formed, which is not always desirable, so the limits of the silicon content in cast iron are usually set. For example, for the main open-hearth and oxygen converter processes, it is desirable to have a silicon content in cast iron in the range of 0.5—0.8%.

Silicon is a mandatory admixture of cast iron and is contained in scrap in one or another amount. Usually the silicon content in the metal charge is quite high (0.5—1.0%). Silica is a strong acid oxide, so the completeness of the silicon oxidation reaction also depends on the type of process, more precisely, the nature of the slag under which the melting is carried out.

In the main processes, silica forms strong compounds in the slag: at the beginning of melting, iron silicates 2FeO• SiO2 and calcium CaO• SiO2, later calcium silicate 2CaO• SiO2. Due to this, the activity of SiO2 in the slag is very low even at its high concentration and silicon in the main processes is oxidized almost completely at the beginning of melting, and during melting it is not restored in noticeable quantities, regardless of the presence of carbon and other common impurities of cast iron and changes in the temperature of the bath. At the beginning of melting, silicon oxidation is promoted by the relatively low temperature of the bath and the high content of FeO in the slag. In the course of melting, the temperature of the bath increases. This causes the reaction to shift to the left, towards silicon reduction, since the reaction is exothermic. However, with an increase in the temperature of the bath, an increase in the basicity of the slag simultaneously occurs, which contributes to a deeper desilinization of the metal with the formation of the most durable calcium silicate 2CaO • SiO2. As a result of the action of these two opposite factors, the residual silicon content in the metal remains approximately at the same level, which is usually 0.01—0.02% [4].

This residual silicon content in the metal does not affect either the course of the process or the quality of the finished steel of conventional grades, therefore, the residual silicon content in the metal is neglected, i.e. it is believed that in the main processes, as a result of oxidative refining, silicon is completely removed from the metal.

In the main processes, the composition of the slag is regulated by the introduction of a certain amount of fluxes (lime or limestone), therefore, regardless of the silicon content in the initial charge, a certain SiO2 content in the slag is obtained, at least by the end of melting. The different content of silicon in the initial metal charge and silica in the non-metallic charge only leads to the consumption of different amounts of fluxes and the production of unequal amounts of slag [5].

In acidic processes, the activity of SiO2 in the slag is many times higher than in the main processes, so the residual silicon content in the metal is much higher and can reach 0.4%. At the beginning of melting, due to the low temperature of the bath and the high FeO content in the slag, silicon is oxidized more completely, its residual content is relatively low (~ 0.05%). By the end of melting, the temperature of the bath increases, and this simultaneously contributes to a decrease in the content of iron oxides in the slag and an increase in the concentration (activity) of silica as a result of its receipt from the lining of the unit. Changing these melting parameters has the same effect on the silicon oxidation reaction — it shifts it to the left, in the direction of silicon reduction. The greatest reduction of silicon is possible when the slag is saturated with SiO2 [6].

Saturation of the slag with silica leads to an increase in its viscosity, therefore, the slag is systematically diluted by the introduction of various basic oxides (iron, manganese, calcium) in the form of iron or manganese ore, lime. At the same time, the activity of SiO2 in the slag decreases, which leads to a decrease in the residual silicon content to 0.05—0.15% [7-8].

In the main processes that are currently crucial in the production of steel, the residual silicon content in the metal at the end of oxidative refining is negligible (traces), therefore silicon as a useful impurity in the required amount is introduced into the metal after the end of oxidative refining. For this purpose, various ferrosilicon alloys, called ferrosilicon, are usually used. Sometimes silicon is also included in the composition of combined alloys, for example, with manganese, chromium, aluminum, calcium and other elements.

Due to the high chemical affinity of silicon to oxygen, when ferrosilicon or another alloy containing silicon is introduced into a steelmaking unit in the presence of oxidizing slag, significant silicon fumes are observed in it. Therefore, it is advisable to introduce silicon not into the steelmaking bath, but into the steel casting ladle during the smelting release.

CONCLUSION

In practice, ferrosilicon is sometimes introduced into the furnace for deoxidation. In some cases, during deoxidation and alloying of steel, not only oxidation, but also reduction of silicon is possible. This usually happens when strong oxidants (aluminum, titanium, etc.) are introduced into the metal in large quantities (0.5—1.0%), and the silicon content in the metal is low. The recovery of silicon from the bucket lining is greatly developed with prolonged stirring of the metal in the bucket during vacuuming and purging with neutral gas. In this regard, vacuuming or neutral gas treatment of metal with a high content of titanium and aluminum cannot be carried out in a bucket lined with chamotte. The bucket must have a different lining, for example, dolomite. During long-term metal processing in high vacuum conditions, silicon recovery from lining and slag is also possible under the influence of metal carbon, since carbon becomes a strong deoxidizer during rarefaction. In this case, the chamotte lining of the bucket is also undesirable.

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