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GUNITING LININGS OF OXYGEN CONVERTERS IN THE COURSE OF MELTING WITHOUT STOPPING THE BLOW

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Problems arising in guniting converter linings in the course of melting without stopping the oxygen blow are considered. Deposition of a mixture based on magnesite is conducted in an oxygen jet. As the powder particles move in the vessel, they are heated due to the heat of the converter and afterburning of carbon monoxide, which ensures their strong cohesion with the surface of the lining. The velocity and diameter of the gas-powder jet are calculated as a function of the concentration of the periclase powder, the distance from the tuyere nozzle, and the temperature of the magnesite particles heated in the vessel. An experimental installation is developed and experiments on guniting in the course of melting without interrupting the blow are conducted. It is established that the gunited coating is deposited on the lining only at the end of melting. The endurance of the coating is 1 – 4 heats. In guniting, the temperature of the metal increases by 20 – 70°C. The experiments showed the possibility in principle of guniting a converter lining in the course of melting without interrupting the blow.

The oxygen converter method of steelmaking is widely used in ferrous metallurgy in Russia. Intensification of steel melting in converters creates severe conditions for the operation of refractory linings. The linings fail due to several causes, the most important of which are the high temperature, the corrosive effect of the slag and the gas medium, and the erosion of the lining caused by the moving gaseous, liquid, and solid phases. All these factors lead to the appearance of local worn regions in the converter lining. The endurance of the lining can be increased by increasing the quality of the refractories used and the differentiated lining, improving the firing regime of the lining, optimizing the parameters of steel melting, and repairing the worn regions of the lining by guniting.

In the present paper we consider problems arising in guniting the refractory lining of a converter. Guniting can be conducted by three methods, namely, semi-dry, pulp, and jet ones. Depending on the fuel used, jet guniting can be solid, gaseous or liquid. The best coatings are obtained with the use of gaseous, or liquid fuel. In Russia the most popular method is jet guniting with coke breeze as the fuel, which increases the endurance of the linings to 1000 – 1500 heats on the average with a consumption of the guniting mixture equal to 1 – 3 kg per ton of steel. In Western Europe, the U.S., and Japan the semi-dry guniting method is preferred, which has made it possible to increase the endurance of the linings to 2000 – 3000 heats with a consumption of the guniting mixture equal to 0.5 – 1.5 kg per ton of steel.

All the methods mentioned for guniting the lining of a converter are legitimate and the choice is determined by the operating parameters of the converter. It should be taken into account that the semi-dry method is the simplest from the standpoint of design and technology, whereas the jet method, which envisages the use of fuel and oxygen, requires appropriate changes in the design of the gun and the technology of guniting.

Other conditions being equal, jet guniting with the use of a gaseous or liquid fuel can give denser and hence more wear-resistant coatings. Therefore, for very severe operating conditions for the converter lining, for example in melting stainless steel, it is more expedient to use jet guniting, whereas in other cases the semi-dry method is preferable.

For any method of guniting we should take into account the critical endurance of the lining above which guniting becomes economically inexpedient. All methods of guniting have a substantial shortcoming, namely, the necessity of shutting the converter down for guniting, which reduces the technical and economic parameters of converter operation. In this
connection, the St. Petersburg Institute of Refractories has developed a new technique for gunmetal converter linings in the course of melting without stopping the oxygen blow. In cooperation with the Tulachermet Research and Production Association the institute has developed an experimental installation for gunmetal converter linings in the course of melting and testing the technological parameters.

In investigating the process of gunmetal the lining of a converter in the course of melting we based ourselves on the fact that at a certain moment of melting the atmosphere above the molten metal is predominantly a gas and liquid one characterized by different local densities. The gaseous phase is mostly represented by carbon monoxide and carbon dioxide and the liquid phase is represented by molten slag and metal.

When the gunmetal powder is introduced into the converter in a gas jet (a gas-powder mixture) the gas and liquid phases interact with its components in the vessel above the level of the metal. The physical picture of the behavior of the solid powder particles blown into the converter seems to be determined mainly by the following parameters: the characteristics of the gas-powder jet at the outlet from the tuyere nozzle, the grain composition of the powder, the aerodynamics of the subtuyere zone, and the hydrodynamics of the reaction zone of the converter.

Under the assumption that the collision of the gas-powder jet with the gas and liquid medium in the vessel above the molten pool is adiabatic, the critical velocity $W$ of the gas-powder jet along the axis of the nozzle can be determined from the equation

$$W = \sqrt{\frac{2g}{k - 1} \frac{k}{R} \left(1 - \frac{P}{P_1}\right)^{\frac{k - 1}{k}}}$$

where $k$ is the exponent of the adiabatic curve of the gas-powder jet, which is usually equal to 1.40; $P$ is the excess pressure before the nozzle; $P_1$ is the excess pressure of the medium into which the gas-powder mixture is fed; $R$ is the gas constant, equal to 26.50 m$^3$/kC for the case of oxygen transportation of the powder; and $g$ is the free-fall acceleration.

The depth of penetration of the gas-powder jet into the converter $h$ can be determined from the equation

$$h = n \frac{W_{\text{mix}} S_{\text{mix}}}{g}$$

where $W_{\text{mix}}$ is the critical velocity of the gas-powder mixture; $S_{\text{mix}}$ is the mean density of the gas-powder mixture; $S_l$ is the density of the liquid phase above the molten metal in the converter; and $n$ is the coefficient of penetrability of the velocity head.

It follows from the equation that the depth of penetration of the gas-powder jet into the converter depends primarily on the density of the gas and liquid medium above the molten metal and the density and velocity of the gas-powder jet. The lower the density of the gas and liquid phase the deeper the penetration of the gas-powder jet. An increase in the density and velocity of the gas-powder jet increases the depth of its penetration too.

In order to check the possibility of gunmetal converter linings in the course of melting without interrupting the blow the Tulachermet Research and Production Association developed an experimental installation (Fig. 1). The installation has the following operating characteristics: the useful volume of the service bunker 2 m$^3$, the excess pressure of the oxygen up to 1.5 MPa, the diameter of the transporting pipe 42 mm, the distance from the gunmetal powder supply to the converter 32 m, stepped control of the powder flow rate, the maximum output with respect to the powder 4.5 m$^3$/h, the concentration of the powder in the gas and powder mixture up to 16 kg per kg of gas.

The experimental installation (see Fig. 1) has a service bunker into which the gunmetal powder is loaded with the help of a special conveyer. A dosing feeder is connected to the lower bottom of the bunker. The bottom of the vessel has six aeration pipes positioned along generatrices of the conical bottom. Each aeration pipe has a gate. The walls of the pipes have openings 5 mm in diameter.

The transporting gas (oxygen) that passed through the layer of gunmetal powder that was fed into the bunker and...