MEASUREMENT OF THE METAL TEMPERATURE IN 50-TON CONVERTERS BY MEANS OF THERMOCOUPLES PROTECTED BY CERMET ZIRCONIUM-BORIDE END CAPS


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The quality of steel and the output and efficiency of converter production during the smelting process depend to a considerable extent on the metal temperature. Therefore, continuous temperature control is necessary during the blowing-through process.

Measurement by means of thermocouples is considered to be the most efficient method for measuring the temperature of the liquid metal. A tungsten-molybdenum, a tungsten-molybdenum with aluminum (Central Scientific Research Institute of Ferrous Metallurgy), a platinorhodium-platinum, and a platinorhodium-platinum PR 30/6 thermocouple were tested during the operation of a 50-ton converter under industrial conditions. It was found that the most stable thermocouple with the necessary metrological characteristics was the PR 30/6 thermocouple. All the subsequent experiments were performed with this thermocouple.

In order to protect the thermocouple from destruction by liquid metal, we used three-layer gastight end caps, which were developed on the basis of heat-resistant zirconium-boride cases.*

The durability of zirconium-boride end caps was basically determined with respect to the chemical action which the slag exerted on them and with respect to the erosion wear caused by metal flow. It is known [1, 2] that zirconium-boride end caps can be exposed to liquid metal in Martin furnaces for several hours. Their high refractoriness and chemical stability in molten steels can be explained by the strong chemical bond of the compound, in which, besides valence electrons, also electrons of internal incomplete electron shells of the element's atoms participate, and also by the structure of borides, where the frame of the crystal lattice consists of boron atoms [5].

The operating conditions of zirconium-boride end caps are more severe in an oxygen converter, since there are large convection currents of nonuniformly heated metal (local overheating is possible), and the temperature in the reaction zone may exceed 2500°C. As a result of this flow, it is possible that the end cap sometimes comes into contact with the converter slag carried by the metal.

The converter reduction slag contains a large amount of ferrous oxide FeO, which constitutes the intermediate compound that transfers the oxygen from the gaseous phase to the interior of the metal for the oxidation of impurities. The slag activity with respect to oxygen is very high. Zirconium and boron have an affinity to oxygen and are actively oxidized at temperatures as low as 800°C. If the slag temperature exceeds 1600°C (which is the case in the converter), the end cap material, regardless of its high refractoriness, oxidizes from the surface, thus forming ZrO₂ and B₂O₃ oxides, which are readily washed away by the slag, during which complex silicates are formed due to the presence of SiO₂ in the slag. As a result, the end cap dissolves in the slag until it fails mechanically in three to eight minutes. Therefore, the protection of the end cap constitutes the main problem.

The design of the converter proper and the caisson of the 50-ton converter are such that the thermocouple can be introduced into the metal only through the casing and the lining of the converter's lower conical part (Fig. 1). In

*The zirconium-boride cases were developed at IMSS, Academy of Sciences, Ukr. SSR, under the supervision of G. V. Samsonov, Corresponding Member, Academy of Sciences, Ukr. SSR.
order to test the resistance of the end caps in the metal, they were inserted through the lining at the same level between the bottom and the slag.

The thermoelectrodes were encased in a narrow alundum tube (Fig. 2), and the junction was placed in an alundum end cap, which was protected by means of a zirconium-boride cap, after which the thermocouple was placed in a metallic tube. After the first experiments, the alundum end cap was made longer in order to protect the thermocouple from shorting by the metal that has penetrated the lining. The misgivings concerning the possibility of the metal escaping through the entrance opening were not justified.

During the first melting after the thermocouple was installed, the molten iron penetrated the thermocouple entrance opening, sometimes even appearing on the outside of the casing, but it solidified, thereby "automatically" sealing the thermocouple. The metallic tube protected the thermocouple from damage during the laying and heating of the lining and also from the moisture in refractory clay.

A deflector (Fig. 2, 1) consisting of one or two bricks was provided above the protruding end cap in order to protect it from being damaged by a piece of brick in laying the upper rows of lining, a piece of ore, or a piece of lime when cooling additions are introduced in the bath.

As was expected, the resistance of the end pieces was greater when they were located closer to the converter's bottom where the amount of slag emulsion in the metal was lower. End caps mounted at the metal surface lasted 5-8 min. At a depth of 200 mm below this level, they lasted 15-19 min. At a level of 320 mm from the converter's bottom, the end caps lasted throughout the entire smelting process.

It has been established by investigations that, in comparison with the chemical action of slag, the effect of metal convection flow on the durability of end caps is negligible. The end caps fitted into the lining (Fig. 1, 3) were screened from the flow by refractory brick. This did not improve their resistance.

Simultaneously with testing the resistance of end caps at the insertion place, we determined the degree to which the temperature readings were representative of the temperature of the converter bath. On the basis of the converter's symmetry with respect to the oxygen stream, we assumed that the convective metal flow and the metal temperature were uniform along the converter's perimeter. With the thermocouples installed at different levels in the metal zone, we recorded the beginning and the rate of changes in the metal temperature at the moment when the cooling admixtures were added and also the rate of temperature increase during the blowing-through process. The thermocouples were mounted at distances of 320 and 800 mm from the converter's bottom.

The placement of the thermocouple at different depths in the metal hardly exerted any influence on the rise

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Fig. 1. Diagram showing the installation of thermocouples in the converter's lining. 1), 2) and 3) Protected thermocouples; 4) deflectors; 2a) end cap; 2b) end cap holder; 2c) packing; 2d) refractory plug.

Fig. 2. Assembled thermocouple. 1) Junction of the PR 30/6 thermocouple; 2) refractory zirconium-diboride end cap; 3) metallic tube; 4) alundum end cap; 5) single-channel capillary; 6) alundum powder; 7) chrome magnesite powder; 8) asbestos; 9) two-channel capillary.