ALUMINOSILICATE RAMMING BODIES FOR LINING INTERMEDIATE LADLES IN CONTINUOUS STEEL CASTING PLANT

L. A. Tseitlin, K. N. Repenko,*
A. K. Mendelenko, and E. V. Merkulova

The directives of the 24th Congress of the CPSU for the five-year plan for developing the national economy of the USSR for 1971-1975 specifies further increases in the volume of continuously cast steel. Therefore, the problem of increasing the life of refractories for continuous steel casting is of great significance. One of the bottlenecks in the continuous casting of steel is the poor resistance of the linings in intermediate ladles made mainly from fireclay ladle brick.

The structure of the intermediate ladles is subjected to the erosive action of liquid steel at temperatures of about 1550°C. The eroding action of steel on the fireclay lining in intermediate ladles used in continuous steel casting is much more intense than in ordinary steel ladles, due to the greater mobility of the steel, especially close to the site at which the jet comes into contact with the lining, and the higher temperature of the lining due to the more prolonged (3-8 h) continuous casting of steel through the ladle. In some factories the short life of the lining in intermediate ladles is due to the damage done to them during removal of the crusts of metal formed during breaks in the casting, and which penetrate deep into the joints [1-3].

In order to increase the life of intermediate ladle linings, following a proposition from the Glavogneu-por of the Ukrainian Research Institute together with the Semiluks Refractories and Novo-Lipetsk Metallurgical factories, experimental work has been done, the outcome of which was the introduction of rammed linings made from high-alumina, shrink-free bodies.

The composition of the body was 66% high-alumina coarse-grained chamotte, 34% finely milled corundum-clay mixture, and 3.5% (on 100% calculated as H₃PO₄) orthophosphoric acid. Upon reaction in service between corundum and the silica of the clay, leading to the formation of mullite, the body shows an expansion which predetermines the monolithic character of the lining. The introduction of orthophosphoric acid into the body contributes to the consolidation and reinforcement of the lining, and improves its resistance to the action of metals and slags [4-9].

The production of high-alumina ramming shrink-free bodies was set up at the Semiluks Refractories Plant. The prepared body packed in polyethylene bags was delivered by railway cars or lorry to the user factories.

The linings were made by ramming with pneumatic tampers with a compressed air pressure of 5-6 atm. The drying of the rammed linings in the ladles is done with a gas burner with a gradual rise in temperature to 1200°C and a soak at this temperature of 5 h. The total drying and heating time for the rammed lining was 24 h. At the Novo-Lipetsk Metallurgical Factory almost all of the linings in the intermediate ladles of the continuous steel plant are being made by ramming high-alumina shrink-free bodies.

The life of the rammed linings on average is about 25 heats, that is, 5-6 times greater than the life of linings made from ladle brick. The maximum wear of the rammed linings is noted close to the site of impact of the jet of metal, and on average equals 1.5-3.0 mm per heat. The wear of the ladle brick in these places reaches on average 14 mm. The cost per ton of steel drops by 11.2 kopeck upon the replacement of brick linings with rammed linings.

*Deceased.
Fig. 1. Irreversible changes in the linear dimensions of rammed bodies as a function of the firing temperature. Notation on the curves indicates body numbers.

Fig. 2. Porosity (a) and compressive strength (b) of rammed bodies as a function of the firing temperature. Notation on the curves indicates body numbers.

Fig. 3. Creep during the loading of 1 kg/cm² on rammed bodies. Nos. 2-4 (notation on the curves) at 1500°C and firebrick at 1400°C (curve 1).

After completing certain measures it is possible to achieve further increases in the life of rammed linings. Usually from one to four heats are continuously cast through an intermediate ladle.

A larger number of heats cannot be cast without stoppage owing to the unsatisfactory service of the nozzles. During the casting of steel with an enhanced concentration of aluminum, and during the casting of rimming steels, constriction or erosion of the nozzle channel occurs.

After casting has ceased metal frequently remains in the ladles, and crusts are formed, the removal of which damages the lining.

During the cooling of the rammed linings the longitudinal walls sometimes develop vertical cracks up to 6 mm wide, as a result of the thermal compression of the body. The cracks which are no more than 2 mm wide are usually closed up during repeat heating. The wider cracks need to be repaired. Small running repairs in various sections of the rammed lining are not always done, and it has to be replaced prematurely.

The possibility of increasing the service of rammed linings is confirmed by their low degree of erosion during service. According to measurements on the linings after service they show irregular wear. The maximum wear (1.5-3.0 mm per heat) occurs in that section of the lining which is located close to the spot where the metal jet comes into contact, and the rest of the lining is worn away by 0.5-2.0 mm per heat. An increase in the resistance of the rammed linings in intermediate ladles can be achieved by reducing the formation of crusts, and removing them without damage to the lining. Timely, minor running repairs made to various sections of the rammed linings also greatly increase their resistance.

Considering the irregularity of the wear, intermediate ladle linings close to the site of jet impact should be made with thickened materials; wear resistant bodies with contents of alumina should be used for this section of the lining. As investigations have shown, instead of standard white electrocorundum it is possible to use electrocorundum waste used at abrasive factories. The composition and properties of the rammed bodies investigated, using various starting materials, are given in Table 1, and in Figs. 1-3.

The starting materials for preparing the bodies consisted of high-alumina chamotte (69.7% Al₂O₃, water absorption 1.5-2.0%), chamotte made from Suvorov clay (41.4% Al₂O₃, 1.58% Fe₂O₃, water absorption 4-5%),