Since a decrease in the loss of working hours is one of the factors which increase the output of blast furnaces, the editorial staff of this periodical invites the readers to comment on the problems raised in the following article.

At present the short life of air tuyeres is one of the main reasons for stoppages of blast furnaces and loss in iron output. The replacement of one single tuyere interrupts the operation of the furnace for 15-30 min and 30-50 t iron is lost. Apart from that, the tuyere replacement is a labor consuming operation and the cost of the tuyere is 90-130 rubles.

The life of air tuyeres varies (from several days to several months) and depends on a number of factors, for instance, on the blast-furnace operation, material of the tuyere, quality of cooling water of the tuyeres and the flow rate at the walls. If the operation of the furnace is smooth, the life of the tuyeres is longer. However, in connection with changes in the operation of the furnace during the whole period of campaign, a tuyere is required which would not be affected by any change in operation of the blast furnace.

The main reason for the breakdown of tuyeres is the burning through of the tuyere wall caused by the molten iron. Usually tuyeres are made of red copper which has a high coefficient of thermal conductivity and a melting point 1083 °C. This is lower than the temperature of the molten iron in the furnace.

The cooling water for tuyeres should contain a minimum quantity of suspended insoluble particles. The air tuyere is hollow. It is like a settling tank for the suspended particles which settle in the lower part of the tuyere and reduce the heat transfer from the tuyere wall to the water. The quality of cooling is poorer and the service life of the tuyere decreases.

The main factor which directly affects the life of tuyeres is the flow rate of water at the tuyere walls. At present the water is supplied at a pressure 1.96-3.9 \(10^5\) N/m\(^2\) (2-4 atm), its consumption is 12-16 m\(^3\)/h, the flow...
rate inside the tuyere is 0.5-1 m/sec. Water with such parameters ensures natural cooling of the tuyeres except for the cases in which instantaneous thermal shock is produced by the molten iron. The temperature rises above the melting point of copper and the tuyere burns through. Therefore, the construction of the tuyere should ensure the transfer of a quantity of heat which is larger than that supplied by the molten iron. In that case the surface of the tuyere will not be damaged.

In 1964, 536 air tuyeres in five blast furnaces of the "Zaporozhstal" Works were replaced. 482 of these tuyeres had broken down because of burning through caused by the molten iron. In 1964 the average life of the tuyeres in the blast-furnace plant was 43 days. The thermal loads per air tuyere per month in furnace No. 5 were investigated and measured before iron and slag tapping, during tapping, with and without gas firing of the furnace. Apart from that the thermal loads were measured at the moment when the molten iron entered the tuyere and the flow rate of water was selected so as to ensure the removal of the critical thermal load.

At a flow rate of water 7 m/sec the copper pipe in the stream of molten iron in the runner did not burn through during five tappings of 35-45 min each, but on reducing the flow rate of water, the copper immediately burned through. The critical thermal load per tuyere was $25 \cdot 10^6 J/m^2 \cdot h$ ($6 \cdot 10^6 \text{kcal/m}^2 \cdot \text{h}$).

The air tuyere of a corresponding construction (Fig. 1) is hollow and made from red copper sheet. It is practically impossible to ensure a flow rate of water 7 m/sec at the walls of the tuyere, and when the thermal shock occurs (when the molten iron comes into contact with the surface of the tuyere), the temperature of the copper wall below the iron rises to the melting point and the wall burns through. This process is very rapid.

Several tuyeres of other constructions were tested in blast furnace No. 2. The combined tuyere (Fig. 2) has a nozzle which consists of two steel coils which are embedded in copper, and its remaining part is hollow. The water enters the coil and the hollow part and then flows into the waste. The water pressure in the tuyere is $1.96 \cdot 10^5 N/m^2$ (2 atm), the flow rate of the water in the coil is 5.2 m/sec. The tuyere was in operation for 106 days. After replacement of the tuyere the second turn of the coil was found to be burned through.

A two-chamber tuyere is shown in Fig. 3. The water first enters the small chamber and then the large chamber and from there it flows to the outlet. The water pressure is $4.9 \cdot 10^5 N/m^2$ (5 atm), the flow rate in the first chamber is 6.3 m/sec. This tuyere was in operation for 68 days. After replacement the large chamber was found to be burned through from below.

18 various tuyeres were tested in blast furnace No. 2 from 1960 to 1964. These tuyeres were packed with high-alumina bricks, covered with pure alumina, lined with chromium carbide, etc. The service life of some of these tuyeres was longer, that of others was shorter compared with the service life of tuyeres of the existing construction. However, all the tuyeres could not withstand the contact with molten iron and burned through.

Only the last, coil-type tuyere (Fig. 4) gave good results. In this tuyere a steel vessel with walls 5 mm thick is welded to the flange. A coil from steel piping 32 mm in diameter is wound around the vessel. Each turn of the coil is welded to the vessel. To preserve the required diameter of the blast channel in the tuyere (180 mm), it is lined with high-alumina bricks. The water first flows into the first turn of the nozzle and then into the remaining turns. A water pressure of $14.7 \cdot 10^5 N/m^2$ (15 atm) was produced by a special pump installed near the furnace. The flow rate of water in the coil was 11.6 m/sec, the consumption 30 m$^3$/h. The tuyere was in operation for 126 days and was replaced for the following reasons. During the stoppage of the furnace some of the tuyeres and nozzles became filled with slag. To clear the slag, one brick was taken out from the blast channel of the experimental tuyere,

![Fig. 3. Two-chamber tuyere.](image3.png) ![Fig. 4. Coil-type steel tuyere.](image4.png) ![Fig. 5. Coil-type copper tuyere.](image5.png)