POSTER

TO THE PROBLEM OF GRAPHITE ELECTRODE CONSUMPTION DURING STEEL SMELTING

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INTRODUCTION

Breakages of graphite electrodes, caused by thermal damage at heightened current capacities, as well as the oxidation of electrodes, leading to the lateral wear, are the main reasons of high electrode consumption in steelmaking electric arc furnaces in Russia.

We investigated the high-temperature oxidation and its connection with thermal stresses and, as a result, with operating resistance of electrodes of different grades (impregnated with pitch and unimpregnated). The investigation of basic types of electrode breakages enables us to propose new criteria describing working conditions of electrodes.

EXPERIMENTAL

The results of the investigation of the oxidation in the temperature range up to 2500 °C are given in Figure 1. The data show that the mass loss rate for unimpregnated graphite is 1.5 times greater than for impregnated one, the diameter reduction, caused by the oxidation of unimpregnated graphite, is 2 times greater than for impregnated one.

The influence of the oxidation, leading to electrode cross-section reduction, was estimated by solving the stationary task of temperature and thermal stresses distributions in the body of electrode of 610 mm diameter, operating at 60 kA current capacity. The task was solved by means of computer program based on the following assumptions (1):

physical and mechanical properties of layers, formed as a result of electrode surface oxidation, are unchanged and coincide with those of oxidized and burned-off layers,

electrode surface, formed as a result of oxidation, is conic, the ruling of the cone being the straight line.

In this case the degree of surface oxidation can be described by the value of the cone vertex angle (α) in the oxidized part of the electrode.

The calculation shows that the electrode oxidation doesn't change the situation of zones of maximum equivalent stresses, which are on the surface with the temperature of 1600-1700 °C, as well as in the case of cylindrical (unoxidized) electrode.

The oxidation of the surface increases maximum stresses in the most loaded part, the dependence of stresses on the degree of oxidation giving relatively straight line (Figure 2). The electrode diameter reduces by 10 % due to the oxidation (from 610 to 550 mm), with stresses being increased by 15 %, i.e. the excessive increase of thermal stresses occured as the electrode was burning.

The service practice allows to classify the most frequently found breakages (Figure 3). Types I to III (breakage over top nipple or socket) are typical in the case of heightened current capacities (more than 15 A/cm^2). These breakages considerably influence specific electrode consumption. Breakages of IV to VI types are typical for medium (5 to 15 A/cm^2) current capacities and influence specific electrode consumption much less.

When electrodes are used at low current

capacities (less than 5 A/cm^2) breakages do not occur.

DISCUSSION

Having heightened oxidation resistance, high-density (impregnated) electrodes provide the reduction of specific consumption caused by the oxidation of lateral surface. They also provide reliable service in a high-temperature zone of arc furnace due to relatively small reduction of the electrode diameter, reducing the risk of breakage caused by thermal stresses.

The nature of electrode breakage to a certain extent describes operating conditions of the electrode. It is difficult to obtain quantitatively the index "Main types of breakages". So we introduced the index "Specific breakages", which is the ratio of the number of breakages of I type to the total volume of electrode consumption. This index to a certain extent describes the electrode losses in a given steelmaking plant.

The use of the index allows to automatize the classifying of plants in accordance with electrode operating conditions.

CONCLUSION

The oxidation of impregnated and unimpregnated electrodes resulting in reducing the electrode diameter was investigated using the method of high-temperature oxidation. The influence of these processes on thermal stresses was estimated. The results show the excessive increase of thermal stresses as the electrode is burning during operation.

REFERENCES

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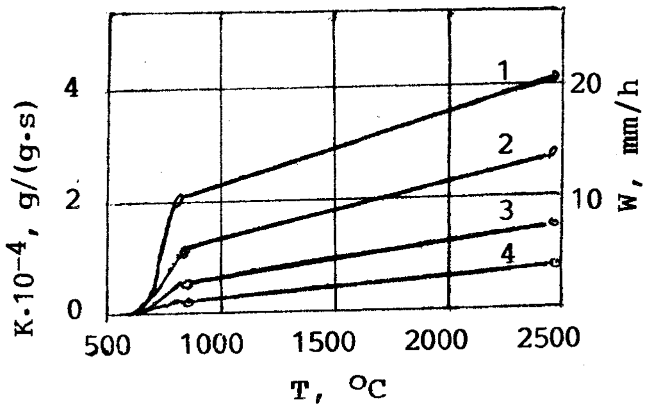

FIGURE 1: Dependence of the mass loss rate (1, 2) and sample diameter reduction (3, 4) of unimpregnated (1, 3) and impregnated (2, 4) graphite on the temperature of oxidation

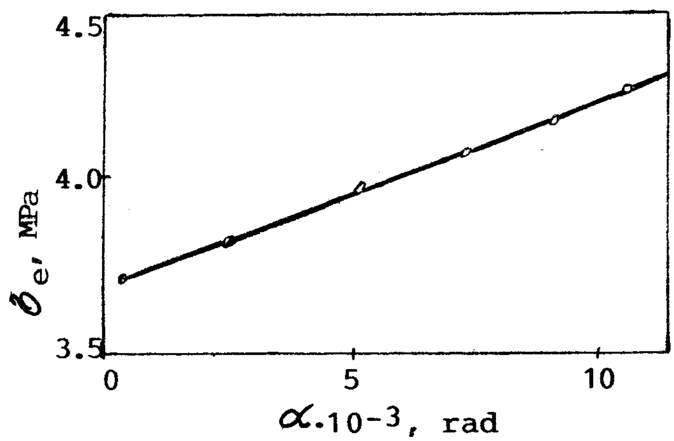

FIGURE 2: The influence of the degree of oxidation of 610 mm diameter electrode on the value of maximum equivalent stresses

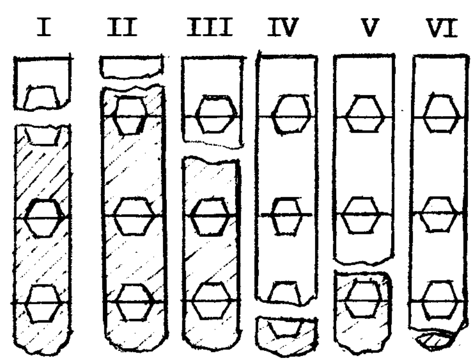

FIGURE 3: Typical breakages of electrodes during operation