POSTER

THE STUDY OF THERMAL STRESSES IN GRAPHITE ELECTRODES OPERATING IN THE ELECTRIC ARC STEEL FURNACES

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INTRODUCTION

The quantity of breakages connected with cracks formed in the electrodes during their operation increases with the increase of power parameters of electric arc furnaces. The reason of cracks formation are thermal stresses arising in the electrode body when the electric current passes through it. The maximum crack formation is developed in the electrodes of large diameters at the current density more than 20 A/cm^2.

The reduction of crack formation and the increase of quality of large diameter electrodes is a complex problem.

One solution of this problem consists in the choice of correct relation between basic physical and mechanical characteristics of material and design of electrode, on the one hand, and operating conditions on the other hand (1, 2).

This article presents the results obtained by development of the mathematical model reflecting one of the sides of the system "electrode-furnace". The model reflects relation between electrode surface temperature, the value of current and thermal stresses arising in the electrode.

EXPERIMENTAL

Comparative analysis of stress loading of continuous electrodes with the diameter of 610 mm depending on the value of current was carried out by solution of the stationary problem of the temperature and thermal stresses distribution in the electrode body, taking into account the temperature dependence of electrode graphite properties.

The solution of the problem includes the following main stages:

1. Analysis of heat sources distribution in the cross-section, taking into account the dependence of specific resistance of electrode material on the temperature.

2. Determination of the stationary axial-symmetric field taking into account the temperature dependence of thermal conductivity of electrode material.

3. Determination of thermal stresses in the cross-section of the electrode on irregular heating and the evaluation of its strength.

The calculations are executed on the basis of the temperature dependence of physical and mechanical characteristics of electrode graphite (Figure 1 (1)).

RESULTS AND DISCUSSION

Maximum thermal stresses (equivalent σ_e, in the along the electrode axis σ_t and in the circle direction σ_θ) arise in the cross-section of the electrode with surface temperature 1600 °C at the current capacity of 60 kA (Figure 2).

Temperature difference along the radius of the continuous electrode attains 260 °C in this cross-section, resulting in the tensile stresses σ_t = 3.7 MPa and σ_θ = 3.7 MPa on its surface (Figure 3).

Stresses in the surface of the electrode increase with the increase of diameter of electrodes and the value of current (Figure 4, 5).

CONCLUSION

Maximum thermal stresses arising in the electrode made of graphite with specified physical and mechanical characteristics during its usage are developed in the cross-section of the electrode with surface temperature 1600 °C.

Surface stresses increase with the increase of electrode diameter and the value of current, raising the possibility of electrode breakages.

Usage of electrodes with axis channel permits to reduce this stresses or to increase current carrying capacity.

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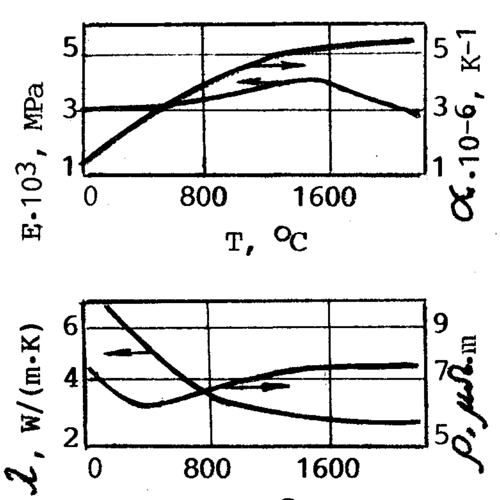

FIGURE 1: Temperature dependence of physical and mechanical characteristics of electrode graphite

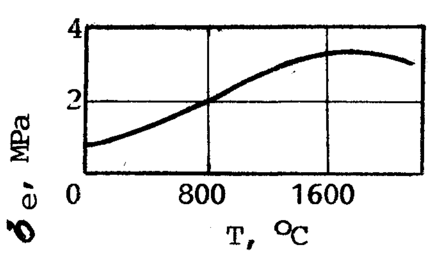

FIGURE 2: Maximum equivalent stresses in the electrode of 610 mm diameter operating at 60 kA

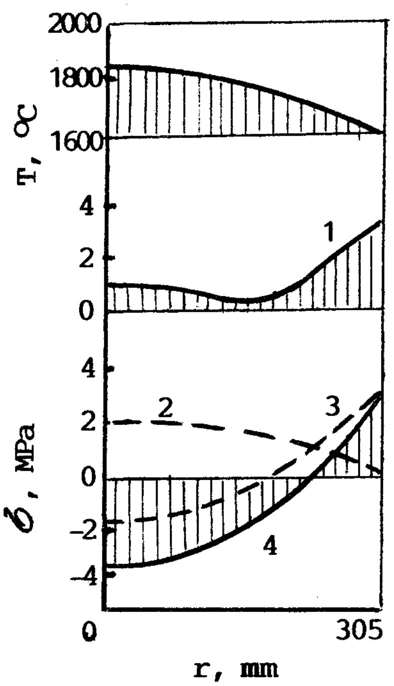

FIGURE 3: Distribution of temperature and stresses along the electrode radius: 1 - equivalent stresses, 2 - radial stresses, 3 - circle stresses, 4 - axial stresses

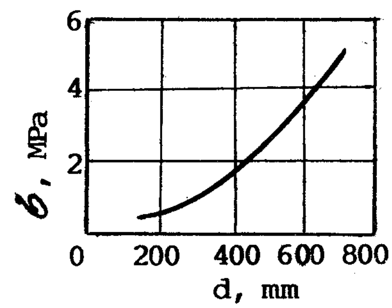

FIGURE 4: Stresses in the surface of electrodes of various diameters

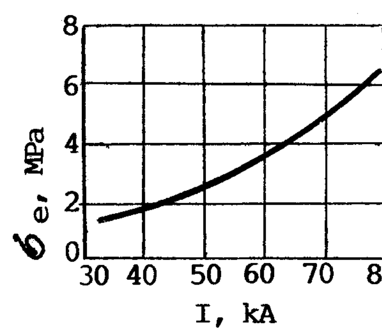

FIGURE 5: Stresses in the surface of the electrode as a function of current capacity