OPTIMIZATION OF TEMPERATURE SCHEDULES OF CYLINDRICAL ELECTRODES OF ELECTRO-ARCH PLASMATRONS

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Now electro-arch gas heaters (plasmatrons) are utilized in many industries widely. One of actual problems which arises at designing of plasmatrons is raising of resource (up-to-time of work) of their operation [1]. In many respects the resource of plasmatrons operation depends on erosion of cylindrical electrodes in a contact zone of electric arch with cylindrical electrode, more exactly, in a heating spot of cylindrical electrode by electric arc [1]. The physical processes of erosion formation are learnt not completely now. One of hypotheses of erosion formation has verified by experiment [2]. In accordance with it erosion value depends on temperature under a heat source. We shall hold on to this hypothesis.

Now gas dynamic and magnetic scan devices have appeared which realize controlled moving of a heating spot on the internal surface of cylindrical electrode in accordance with predesigned periodic law [1]. The appearance of such devices allows to put forward the problem of optimal control by the heating spot moving with the purpose of deriving minimum erosion of cylindrical electrodes and to utilize for a solution of this problem methods, designed for research of systems with mobile control [3,4]. In this report are represented statement and solution of the problem of optimal control by the heating spot moving for the electro-arch plasmatron.

The physical statement of the control problem by the heating spot moving is following (Fig.1). On an internal surface of the cylindrical plasmatron electrode 1 is displaced a spot of

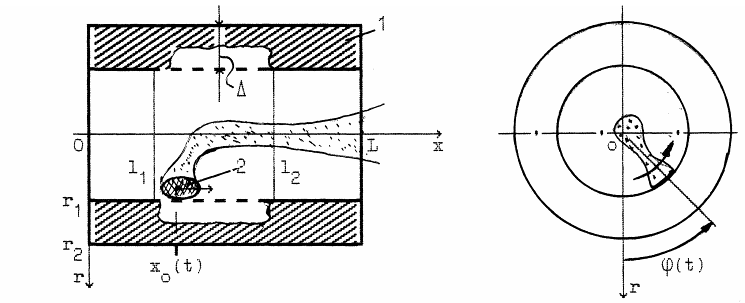

Fig. 1

heating 2 which is created by an electric arc (this is mobile source of action). Coordinates $x_0(t)$ and $\varphi(t)$ are the center position of the heating spot in each instant. Motion along axis x is periodic with a period T_x. $x_0(t) \in [l_1, l_2]$, l_1, l_2 are assigned numbers. Motion along circle has constant radial velocity, time T_φ., and $T_\varphi << T_x$. Δ is maximal erosion value after some time T.

The control problem can be delivered as follows. It is required to find a periodic law of source motion $x_0(t)$ (source power is constant), which for a fixed time interval T ensures the minimum of erosion value.

Up-to-day one-dimensional mathematical models for calculation of temperature field of a plasmatrons electrode are well-known. In these modes heating spot exposure is imitated by an impulsive heat source acting on the plant boundary [1]. Such models allow receiving representation about oscillate component of temperature electrode field but do not give representation about an average temperature field of electrode.There are utilized the following models of plasmatron electrode for calculation of optimal motion law in this report.

1. Spatial one-dimension model. The state $Q(x,t)$ of the rod by length of L is described by heat-conduction equation with boundary conditions of 3-rd kind and mobile exposure as following

$$F(x,t) = p(t)\psi\left[x - x_o(t)\right], \tag{1}$$

including in right part of equation. Here $p(t)$ is source power, $\psi(t)$ is spatial power distribution in the heating spot exposure (normalized Gauss's function), $x_0(t) \in [l_1, l_2]$ is the motion law of source (required control).

2. Spatial two-dimension model – cylinder with coordinates x, r (Fig.1). So far as $T_\varphi << T_x$, approximately it is possible to consider that the heat source (1) evenly distributed on the ring of radius r and this ring-like source is displaced lengthwise axis x under the periodic law $x_0(t)$. Thus temperature field will depend only on coordinates x and r. Then the search problem of distributed control can be delivered as follows.

Let there is known constant source power $p(t) = p = const$. It is required to find the control (periodic function) $x_0(t) \in [l_1, l_2]$ which ensures the minimum of maximal temperature value of one-dimensional plant or minimum of maximal temperature value on the surface $r = r_1$ of two-dimension plant in steady state. Differently it is required to minimize the functional:

$$\mathrm{I} = \max_{0<x<L} \bar{Q}(x, r_1) \to \min . \tag{2}$$

As far as a mobile source acts on the plant periodically for a long time it is possible to consider, that in plant quasi-steady state is attained when its temperature field has became periodic function of time. Then it is possible to substitute the mobile control by distributed control $\bar{F}(x)$ averaging for a period T_x,temperature thermal field by averaging temperature field $\bar{Q}(x,r)$ and as equations of plant it is possible to consider associated stationary equations which is not depended on time. [4].

The following statement is proved for spatial one-dimension plant. The minimal value of the functional (2) is reached at such control $\bar{F}(x)$ which ensures random temperature distribution of on the cut $[l_1, l_2]$. The optimal distributed control for two-dimension plant is counted. On optimal distributed control $\bar{F}(x)$ it is counted the law of-periodic motion of the source $x_0(t)$ which minimizes the functional (2). The results of numeric calculations are demonstrated.

Literature

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