UDC 621.3

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DEVELOPMENT OF LOW TEMPERATURE HEATING OF METAL IN CHAMBER THERMAL FURNACES

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The questions of development of heat work of chamber thermal furnaces at the low temperature heating of metal and use of a few types of gaseous fuel are considered. The system of automatic control the thermal mode in these furnaces during work with the use of two types of gaseous fuel is worked out.

Keywords: chamber thermal furnace, metal, low temperature heating. two types of gaseous fuel

On metallurgical plants of Ukraine the chamber thermal furnaces of the low temperature heating to 600-700 °C are wide used [1].

Statement or problem. The task of work is research of two variants of control by the heat mode of chamber thermal furnaces: on the size of expense coefficient for air and by the change of calorie content of fuel.

Basic part of researches. Burner devices with the wide turn-down of thermal power and coefficient of expense of air, which worked out in works [2,3], allow to carry out varying by the thermal modes of operations of furnaces: to change thermal power and expense coefficient for air in a wide range.

The modernized burner devices are inculcated on the different constructions of furnaces of PAJ «Electrometallurgy plant «Dneprospetsstal′», that allows to carry out on one furnace heating of metal under forging to the temperature 1270 °C, thermal treatment and cooling to the temperature 200 °C.

Present possibilities of burner devices allowed to execute the experimental heating of metal at the variable expense of fuel and constant expense of air in the conditions of realization of the mode of thermal treatment with a decrease in a temperature to 650 to 200 °C. Here the size of expense coefficient for air was changed in a range 1-5.

The results of researches allowed to set that in period of temperature rise the expense of gaseous fuel has a maximal size and during all this period does not change. In the period of self-control of metal in a furnace the level of temperature in its work volume is supported at maximal level, and the expense of fuel falls down. In the period of cooling of metal temperature in a furnace goes down, and the expense of fuel aspires to the zero, and the expense of air in all periods remains permanent.

As results of exploitation showed, perfection of the modes of thermal treatment of metal and realization of control the expense of fuel at the permanent expense of air on different furnaces and modes of thermal treatment is provided evenness of heating on volume of furnace and bars.

The second variant of improvement of heat work of chamber thermal furnaces is possible at a separate serve on the furnace of a few types of gaseous fuel. In this case the task of determination of composition of gaseous mixture can be presented as a task of the linear programming [4].

In conditions of the linear programming a task can be formulated as follows: at every time composition of the mixed mixture is determined, providing a minimum of cost of heating :

$$C = C_1 \cdot X_1 + C_2 \cdot X_2 + ... + C_n \cdot X_n = \min \quad (1)$$

at presence of limitations

$$q_1 \cdot X_1 + q_2 \cdot X_2 + ... + q_n \cdot X_n = Q_{\text{âí}} \ ; \quad (2)$$

$$V_1 \cdot X_1 + V_2 \cdot X_2 + ... + V_n \cdot X_n = V_{\text{ãã}} \ ; \quad (3)$$

$$X_1 + X_2 + ... + X_n \leq \tilde{O}_{\text{ãîð}} \ , \quad (4)$$

where X_1, X_2. X_n - a current value of charges making mixtures of fuel on heating of metal, m^3/hour; C_1, C_2. C_n - dimensionless gravimetric coefficients; q_1, q_2,.q_n - specific enthalpy of making mixtures of fuel, kJoul/m^3; $Q_{вн}$ - thermal power, kW; $V_{гг}$ - a general expense of making mixtures of fuel, m^3/hour; $X_{гор}$ - a maximal productivity of burner devices on gas, m^3/hour.

As an example examine the task of being of the optimal mode of heating of chamber furnace for heating of material blanks for forging, working in the turn-down of the thermal loading of $Q_{вн}$ from 300 to 800 kJoule/s.

As a fuel use natural gas calorie with content of 33500 kJoule/m^3 and blast-firnace gas with calorie content of 3350 kJoule/m^3. On results the calculations of burning of fuel at the expense coefficient for air α = 1.15 determined the specific volume of products of burning for natural gas $V_{прг}$ = 11.11 m^3/m^3, for blast-furnace gas $V_{дг}$ =1.70 m^3/m^3. Specific enthalpy of cold air is accepted equal i_a = 41 kJoule /m^3.

For the accepted conditions the system of equations is presented in a kind:

$$33500B_{\text{ïðã}} + 3350B_{\text{äã}} + 41B_{\text{èçá.â}} = Q_{\text{âí}} \ ; \quad (5)$$

$$11{,}11B_{\text{ïðã}} + 1{,}7B_{\text{äã}} + B_{\text{èçá.â}} = V_{\text{ãã}} \ , \quad (6)$$

where $B_{прг}$, $B_{дг}$, $B_{изб}$. - expense accordingly natural, blast-furnace gases and surplus air.

The general volume of warming gases, participating in a heat exchange, is chosen from the conditions of the rational gas-dynamic mode and general productivity of burner devices $V_{гг}$ = 0.25 m^3/s (900 m^3/hour). The function minimized in this case looks like :

$$C = 1{,}14B_{\text{ïðã}} + ,1B_{\text{äã}} \ . \quad (6)$$

It ensues from the got results, that in the range of the heat loading from 300 to 500 kJoule/s as a fuel it is expedient to use blast-furnace gas only, and in the range of the middle heat loading from 500 to 600 kJoule/s is natural gas.

Conclusions. The results of the executed researches allowed to set that in the conditions of PAJ «Electrometallurgy plant «Dneprospetsstal′», where use four variants of fuel: blast-furnace, coke and natural gas, and also their mixtures, it is possible to realize two variants of heating of low temperature furnaces with the different types of gaseous fuel, allowing to optimize their work on the specific expense of fuel on heating of metal.

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