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SYSTEM OF AUTOMATIC CONTROL OF THE UNIFORMITY OF HEATING OF THE LAYER OF PELLETS ON A CONVEYOR ROASTING MACHINE

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Abstract. Research in the field of creation of effective methods and means of automation of the process of firing pellets on the conveyor of the heating machine is an important task. To solve this problem, the structure of ATS uniform heating of the surface layer of the pellets, which uses a variable control of the cost of natural gas on each of the main burners. At the same time to run them apply flame the pilot burners operating on the principle of binary control (on, off). Throttle valves driven by a synchronous servo regulated gas flow to the main burners. Studies have shown that the use of such actuators with inverse negative correlation can accurately determine the position of the regulatory authorities. To control the gas flow to the pilot burner is sufficient to use valves with electromagnetic actuators, which are able to take only two fixed positions. The principle of operation of SAR is to maintain the temperature set points on the surface of the layer of pellets on user specified level. The temperature control is conducted on the basis of data obtained from four control points of the surface of the pellets. The basis of the draft automation APCS based on the functional diagram of the management process of burning pellets, updated material and technical base of the existing system of regulation, which uses modern primary transformers, large integrated circuits, specialized controllers and another element base.

Keywords. Automatic control, uniformity, pellets, conveyor roasting machine, heating

Introduction. As a result of the combustion of natural gas to pipeline heating machine changing temperature of the layer pellets, as this process affects the number of allocated heat. Due to the flow of warm air that enters the zone annealing zones of recovery and cooling, the heat from the combustion gas should uniformly distributed throughout the layer pellets. However, when the burner is probable uneven heating pellets, as areas that are under the direct influence of the burners receive more heat than the central layer of pellets. A similar situation also arises in non-uniform permeability layer pellets or change the velocity of the pallets heating machine, etc. [1-3]. In addition, the automation process iron ore oxidized pellets roasting in the oven conveyor kiln car to date is also the problem of energy savings, since fuel costs significantly affect the cost of the finished product.

Simple ways to save energy – is a reduction of the thermal conductivity of refractory materials, reducing their thermal inertia, and so on. In this area played a significant role in the use of heat, fencing designs fibrous materials and products based on them. Over the past 30 years in this direction was made quite significant discoveries. Reduce fuel consumption allows the use of modern burners and control systems, which provides for the possibility of active recirculation of combustion products and alignment furnace temperature field with a relative error of 5 °C.

Especially effective is a comprehensive solution to the question - replacing traditional fireclay bricks products based on fiber installation of radiation-convective energy recovery and use of modern burners with automatic fuel control system. The complex of these solutions can not only reduce fuel consumption by 20-25%, but also increase the productivity of the thermal unit to 20%. Among those using high fiber and products based on them, which are capable of withstanding high temperatures (1500 °C) and have low thermal conductivity, has created entirely new design of furnaces and application of modern primary converters, large-scale integrated circuits, microprocessors, controllers and specialized another element base, make it possible to equip the machine conveyor Lime latest System of Automatic Control (SAC).

The current state of automation conveyor heating machine does not fully identify the main thermal regimes of [3, 4]. Difficulty removing real performance temperature control burning in the layer of pellets cannot get controlled data that can be used to enter into the ACS process of heat treatment on a conveyor pellet heating machine. Today actively conducts research in the development of effective methods and tools that will solve this problem [1-10].

The aim is to study the need for and development of the ACS, which provides uniform heating layer pellets along the width of the conveyor pallet in the oven.

Materials and methods. The proposed ACS smooth flow control using natural gas for each of the main burners. To start using their pilot flame burners that operate on the principle of binary control (on, off). The gas flow to the main burner (hereinafter simply burners) are regulated throttle, driven in synchronous servomotor movement [11]. The use of actuators controlled by negative feedback connection allows you to accurately determine the position of regulators. To control the supply of natural gas to the pilot burner valve enough to use with electromagnetic actuators that are able to take only two fixed position.

The principle of the CAP is to maintain the temperature set points of the surface layer of pellets on the user defined level. Temperature control is based on data from four control points pellet surface. In practice, the temperature reading is advisable to use partial radiation pyrometers "thermoscope-600-1S" [12]. Anchor points are selected uniformly distributed along the line connecting the centers of both areas of direct influence burners, with two extremes are away from the sides of the conveyor to prevent impact to show pyrometer temperature side bed [13]. Fig. 1, and an exemplary location reference points 1, 2, 3, 4 on the surface of the investigated area layer pellets. ACS is the input variable desired temperature at reference points. The initial values are the measured using a pyrometer temperature reference points in the surface layer of pellets.

Block diagram of the studied model is shown in Figure 2. CAP as well. In the above structural scheme as a control object selected model temperature distribution in the layer pellets described in [], but in practice this will take place real object management. The input SAR filed desired temperature satisfying technological conditions roasting pellets. Control element compares obtained from the measuring element temperature values at reference points of desirable and generates control signals that carry information regarding changes in natural gas on the left and right burners. In accordance with these actuators, are synchronous servomotor, gradually change the position of regulators (throttle) on each burner, causing changes in the cost of gas. For optimum ratio "air-gas" depending on the cost of natural gas is regulated by the flow of air to the antechamber and directly up to the burners. On the structural diagram of the calculation of proportions "air-gas" is not shown, because the object model management believed that air enters the optimum for complete combustion of the fuel quantity.

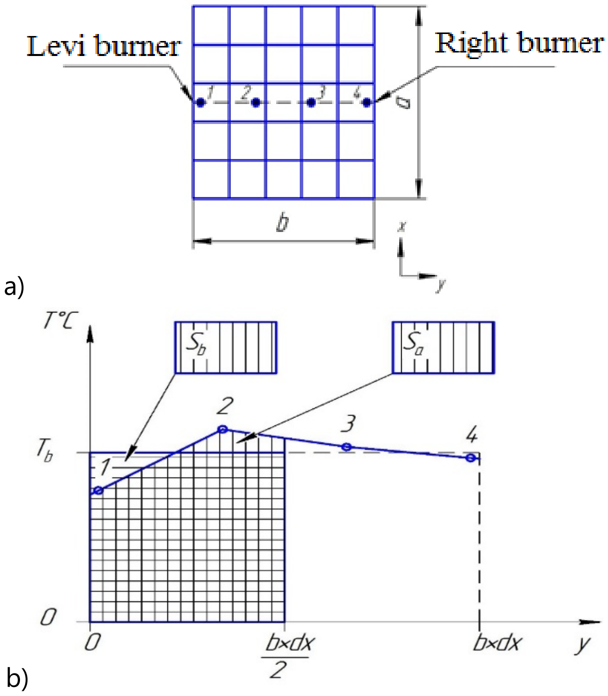

Figure 1. Location of control points on the surface layer of pellets investigated area (a)and presentation of measured values and the desired temperature of pellets in the zone of influence of the left burner as space and (b)

As a result, combustion control output object temperature field is formed, some of which are fixed values measuring unit (group of four pyrometers). Measurement results re-sent to the control element. SAR has two independent circuits control the left and right burners, each of which individually regulated natural gas consumption. To ensure the stability of transients in control circuits used PID controllers. On the structural diagram regulators are not made in separate blocks, and are considered part of the general controls. Functional diagram CAP uniformity of heating layer pellets is shown in Fig. 2b.

Control signals in both control circuits are formed based on the values of temperature control points: - on line left burner - control circuit in the right burner. The desired temperature surface layer of pellets is set at the entrance SAR value. Since the developed system contours to control each burner are the same and independent of each other, the only detail the formation of natural gas burner on the left.

To determine the error pellet temperature control in the area of direct influence of the left burner is necessary to calculate the difference between the expected and measured values of temperature. For this reason, will present the latest in a square shape, which are shown in Fig. 1b.

The figure is limited coordinate axes *T* and y, and direct $T = T_b$ and $y = \frac{b \cdot dx}{2}$ has an area S_b, whose value is proportional to the desired temperature pellets. According to the measured temperature at reference points 1 and 2, along the axis coordinates are known in advance, calculated values of the area S_b. Error value of the system ΔS_L calculated by the formula (1).

$$\Delta S_L = S_a - S_b \qquad (1)$$

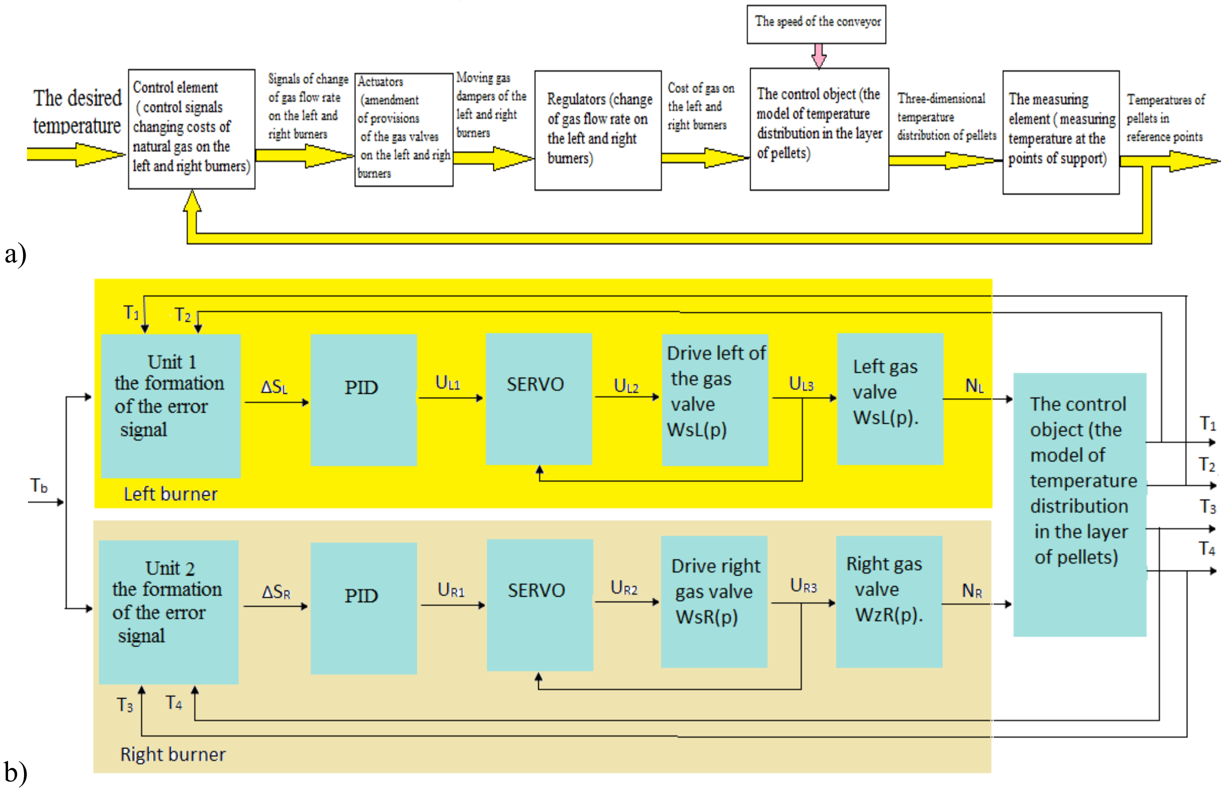

Figure 2. Structural (a) and functional (b) CAP schemes uniformity of heating layer pellets

The figure is limited coordinate axes T and y, and direct $T = T_b$ and $y = \frac{b \cdot dx}{2}$ has an area S_b, whose value is proportional to the desired temperature pellets. According to the measured temperature at reference points 1 and 2, along the axis coordinates are known in advance, calculated values of the area S_b. Error value of the system ΔS_L calculated by the formula (1).

$$\Delta S_L = S_a - S_b \qquad (1)$$

It should be noted that in case of equality ΔS_L zero temperature at reference points 1 and 2 does not necessarily correspond to the desired value, as calculated in the area S_a lack of temperature at point 1 offset its abundance in point 2 and vice versa. However, in this case the natural gas remain unchanged, because the uneven temperature field independently changed due to heat.

Based on the error adjustment ΔS_L PID controller generates a control signal U_{L1}, that the input block SERVO, which in practice serves an integral part of the synchronous servo, but for clarity in the scheme, he made a separate unit. SERVO forms the angle of rotation axis electric U_{L2}, whose value is measured in radians and varies that are able to provide a range of changes in the degree of openness flap U_{L3} from 0 to 100%. In the change of the angle of rotation of the principle of three positional regulation [15]. Box SERVO control is used for reverse negative communication, and therefore for its correct operation must get value the degree of openness flap U_{L3}.

According to the changes the angle of rotation U_{L2} electric gas damper left anther changes its position. Transfer function over $W_{SL}(p)$ described oscillatory link. Since the implementation of the CAP developed in the Simulink environment drive is given a separate unit with built-in libraries, it is not necessary to calculate the parameters of the forward transfer function. The initial value of the electric unit is openness flap that is determined by the U_{L3} and measured in percentage (100% - maximum capacity throttle).

Transfer function of the gas burner left flaps $W_{ZL}(p)$ can be represented as a proportional level of gain, corresponding to its maximum capacity. According to the value of U_{L3} the output power flaps formed natural gas consumption N_L, *m*^{3}*/h*.

Similarly, the value is the formation of gas flow on the right burner N_R. However, in this case to calculate the errors of the system used temperature T_3, T_4. Formed natural gas consumption N_L and N_R the input control object that presented previously developed model of temperature distribution in the layer pellets [13].

The output of control object temperature is set at four reference points (Fig. 1) T_1, T_2, T_3, T_4. To determine the temperature change at the end of the time interval *dt* each block layer pellets, which are in the areas of direct influence of the left or right burners should use the formula:

$$\Delta T_L = \frac{Q_{KL}}{c_0 \quad m_0 \quad n_e} = \frac{K_e \quad ККД_{п} \quad N_L \quad q_z \quad dt}{c_0 \quad m_0 \quad n_e}, \quad (2)$$

$$\Delta T_R = \frac{Q_{KR}}{c_0 \cdot m_0 \cdot n_e} = \frac{K_e \cdot ККД_{п} \cdot N_R \cdot q_z \cdot dt}{c_0 \cdot m_0 \cdot n_e}, \quad (3)$$

where c_0, m_0– specific heat and the weight.

Depending on the speed of the conveyor pallet positions chosen for the study of horizontal lines gradually moved from the beginning to the end of the gas chamber. Schedule changes over time temperature distribution along the width of the conveyor belt on the surface layer of pellets in the gas chamber within the study given in Fig. 3.

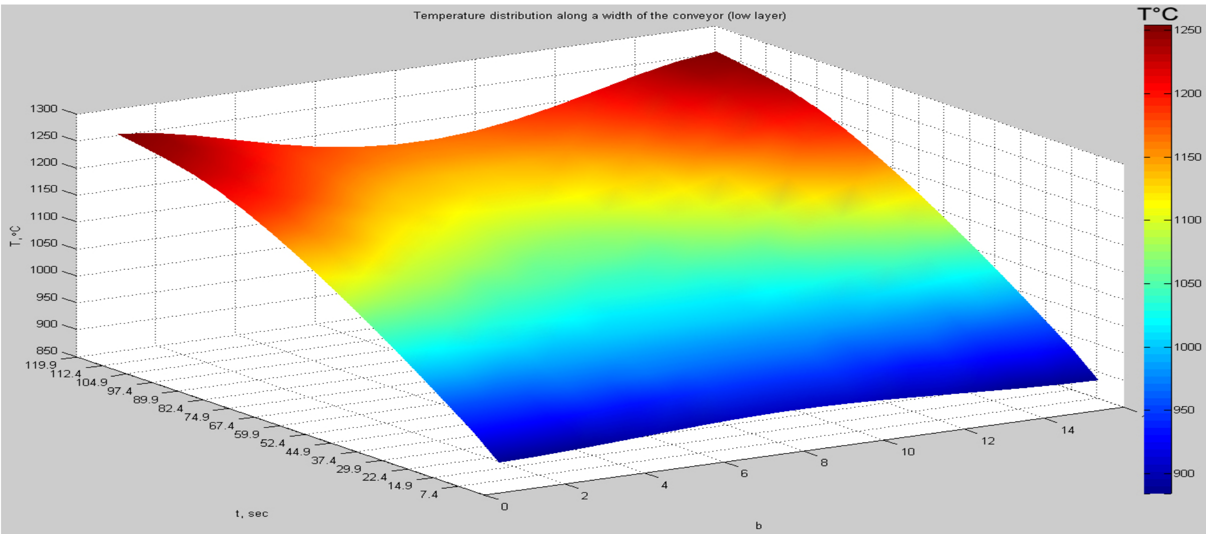

Figure 3. Schedule changes over time temperature distribution along the width of the conveyor belt on the surface layer of pellets in the gas chamber within the study

Conclusion. Developed ACS is designed to control the uniformity of heating the surface layer of pellets along the width of the conveyor pallet in the oven in a single gas-chamber. The system includes two independent circuits control the left and right burners, each of which is separately controlled natural gas consumption. Method of calculation of errors temperature control pellet was based on its geometric interpretation. To ensure the stability of transients used PID controllers.

As the measuring elements suggested to use a system of four partial radiation pyrometer "thermoscope-600-1S."

In developed ACS used smooth control of natural gas to the main burner and binary control - the pilot. Regulators are throttle. As actuators suggested to use synchronous servo. The basis of the change in the angle of rotation about the axis of the principle of three positional adjustment.

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