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Pellets Temperature distribution on a conveyor roasting machine

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Abstract
Aim of this article is a method and results of modeling of heat transfer and thermal radiation processes along the width of conveyor pallet of pellets layer of temperatures in separate air-gas chamber on a conveyor roasting machine using Matlab Simulink software environment.
Key words: CONVEYOR ROASTING MACHINE; CONVEYOR PALLETS; GAS CHAMBER; WIDTH OF PELLETS LAYER; MODEL; TEMPERATURE

Problem statement

Conveyor roasting machines (CRM) continue to be one of the main units, which conducted thermal firing of iron ore pellets. Due to the economic conditions currently, placing into service of new machines has stopped and efforts of developers focused mainly on reconstruction of existing equipment. Efficiency upgrading of CRM is connected with the widespread introduction of advanced production technology and automated systems for process control in order to reduce fuel consumption for manufacturing of finished product and the pressing need to increase productivity of conveyor roasting machines to ensure the required quality of pellets.

Deterministic mathematical models are in the basis of the existing process control systems of thermal firing pellets on CRM. The structure of these models includes a number of parameters that in real operating conditions vary over a wide range by external disturbances not controlled. However, when choosing the individual settings of regulators control loops, using specific values of the parameters that do not always correspond to the real value. This leads to the fact that the existing control systems do not ensure compliance of desired program of thermal firing of pellets on CRM, thus worsening their quality and irrational use of energy. Therefore, the main directions of works in this regard is the use of automated control systems of thermal processes using modern burners with primary converters to control the temperature conditions in the gas chamber on CRM, specialized controllers for the collection and processing of measured data and formation of control signals of the processing equipment.

Analysis of research and publications

The existing CRM structures allow to monitor and maintain the temperature at a given level in different technological areas. However, more important is adherence to the uniformity of heating of pellets layer along its width, which is not controlled in modern CRM [1-2]. Therefore, thanks to the work of native and foreign scientists there studied the process of thermal burning of pellets in order to formalize its basic laws and automation that will implement into production local systems of automatic stabilization of parameters of temperature and gas-burning mode [3-7]. However, such systems do not always allow providing desired temperature regime of burning process of pellets and minimizing energy costs. This can be explained by the fact that while process control there is no possibility of taking into account a number of parameters that play a role of uncontrolled disturbances and lead to violations of technological regime and, consequently, impair quality indicators of process temperature of processing pellets. Researches in the development of effective methods and means of heating the layer of pellets on CRM pallets, are actively fulfilled, but the results of operating shows that modern automation systems do not allow to affect fully the basic temperatures of [8-11]. Difficulty of removing of real indicators of firing temperature in the layer of pellets does not allow to get controlled data that can be used to enter in System of Automatic Control (SAC) of thermal burning processes of pellets on a conveyor roasting machine.

Objective statement

The goal of research is to improve the efficiency of the heat treatment process control of pellets in technological areas on CRM by developing complex automated control systems of thermal burning of pellets. This system makes periodic identification of process of heating or cooling of pellets and performs optimization and control in real time based on the theory and methods of determining the optimal heat treatment process of CRM pellets in areas. This automation process problem is solved using heat transfer model based on the laws of heat transfer and thermal radiation to determine the uniformity of the heating layer of pellets along the width of the pellets layer in CRM.

Presentation of the material and results

Using mathematical model and method of heat treatment of pellets on CRM provided in [12], using developed mathematical model and software environment Matlab Simulink, the process of thermal burning of pellets is investigated. To determine the temperature distribution along the width of the pellets layer there defined two horizontal lines in it. Schematically areas of pellets layer are presented in the form of three-dimensional array of the size [a, b, h],

where two horizontal lines with dimensions [1, b, 1] and are parallel to the y-axis at 1 and h height respectively. This model takes into account two main types of heat exchange: due to heat conduction and by virtue of heat radiation, the motion of conveyor belt and initial heating of pellets entering the investigated area.

Depending on the speed of the conveyor belt, positions of chosen for the study of horizontal lines are gradually moving towards x-axis from the beginning to the end of gas chamber. Initial heating of pellets shown in Fig. 1, was selected as uneven with surface temperature from 1100 to 1200 C.

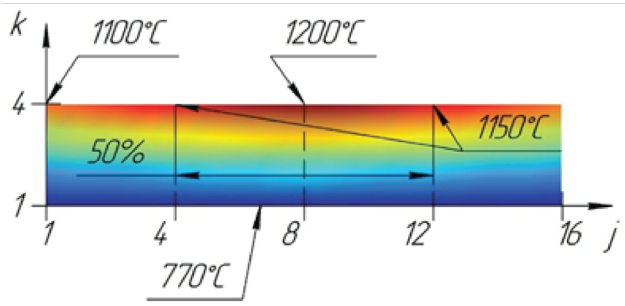


Figure 1. Vertical section of the preliminary heating of pellets layer

When calculating the combustion heat of natural gas in the model, there taken into account the efficiency of burners and composition of the fuel used. There provided independent heating by each of pellet burners located in the zone of direct influence. Along with this, there also taken into account heating of pellets as a result of joint influence of left and right burners. This allows calculating the cost of air required for complete combustion of natural gas. Calculations are based on the chemical composition of fuel. There also considered excess air ratio, depending on the type of burner and level of automation of the fuel supply system. To ensure the stability of the applied transients, PID regulators are used. There suggested to use a system of four partial radiation pyrometers "Thermoscope-600-1S" as measuring elements.

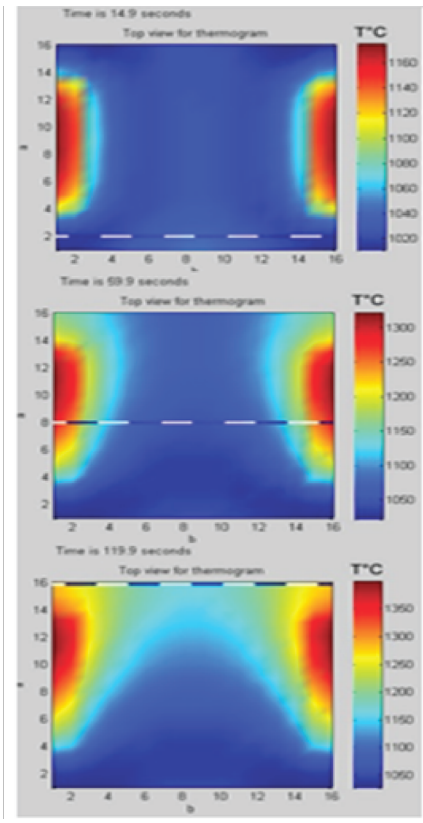
The main program is presented as a combination of four major functions that interact via parameters, initial values and global variables. Sampling interval of Simulink-models is selected as equal to 0.1 s.

In the developed software visualization of simulation results is timplemented. Distribution of Average temperatures of pellets layer is presented in the form of colored graphs of surfaces. Numerical values of user-defined temperature range of component blocks of pellets layer may be brought into the table. Additionally there displayed values of air flow that is necessary for complete combustion of natural gas in each of the burners. The model allowed to determine the temperature along the width of the conveyor pallet on the surface and at the base layer of pellets within the studied gas chamber and determine the effect of natural gas at each of the burners for uniform of heating of pellets.

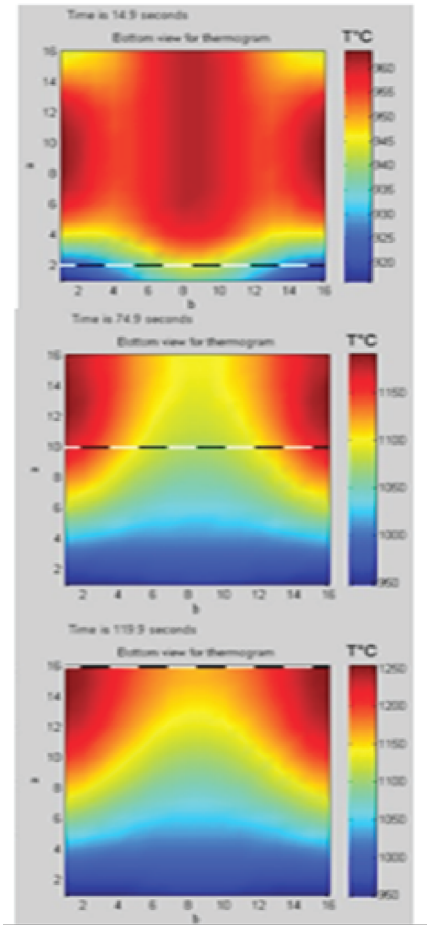
Three-dimensional graphics of changes over time of temperature distribution along the width of the conveyor pallets on the surface of pellets layer within the studied gas chamber are shown in Fig. 2a, and in the base of pellets layer - are shown in Fig. 2,b respectively.

Conclusions

Investigation of heat transfer in the pellets layer allows to develop automatic control system that will operate not point temperature values, measured in certain positions, but temperature distribution throughout the object management. In such systems, it is advisable to use thermal pyrometers or group that will determine the temperature field of the surface of pellets layer. Using the model heat transfer, one can predict the temperature change of control object basing on the values of current natural gas consumption for each of the burners, wich will allow to use fuel effectively. Cost-effectiveness of the studied model will be formed on the base of redistribution of natural gas between burners to ensure uniform heating of the layer that will affect the improvement of the quality of final product due to the adherence to specification of thermal processing conditions of pellets.



a)



b)

Figure 2. Temperature distribution on the surface (a) and in the base (b) of pellets layer at some point of time (the current position of the top horizontal line is indicated with dashed line)

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