Investigation of temperature distribution along the height of the layer of pellets on conveyor roasting machine

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Abstract
Using the model of temperature distribution in the gas chamber in a separate environment Matlab Simulink Modeling, there simulated processes of heat transfer and thermal radiation along the height of the layer of pellets. The simulation results can be used when applied in industry ACS of heat treatment process of pellets. The model is flexible and considers the main parameters of the process annealing pellets. The resulting graphs of changes over time temperature distribution along the height of the layer of pellets are true.
Key words: PIPELINE HEATING MACHINE, PELLETS, MODEL, TEMPERATURE

Problem statement

Increasing requirements for product quality, reduce of its cost and improving the environment around steel enterprises are important conditions for improve of conveyor roasting machines (CRM) and improve of the conditions of workers. During development of this process there is a problem of energy saving – reduction of fuel consumption for finished production, as fuel costs affect significantly the cost of the finished product. Simple ways to save energy - is improving of production of iron ore oxidized pellets by effective management of the roasting process, which provides improvement product quality and increase of productivity of CRM [1-2]. Existing structures of CRM allow to regulate and maintain at set level averages of temperatures in various technological areas. However, more important is compliance and regulation of uniformity of heating of pellets layer along its height, which is not controlled in modern CRM.

Analysis of latest researches and publications

Today there actively conducted researches in the field of development of effective methods and means of heating of the layer of pellets on pallets CRM, [1-7], but the results of operation show that, the current state of automation does not fully affect the basic thermal modes [8,10]. Difficulty of recording of real values of temperature regime of burning in the layer of pellets does not allow to obtain controlled data, which can be used to introduce into SAR process of heat treatment on CRM pellets.

Statement of the problem

Determination of optimal heat treatment process of pellets in the zone of annealing of CRM and automation task of process using heat transfer model based on the laws of heat transfer and thermal radiation requires determining the uniformity of heating of pellets layer along the height of the layer of pellets in the furnace, which is the main purpose of the study performed. This will reveal basic laws and peculiarities of formation of temperature field of pellets layer.

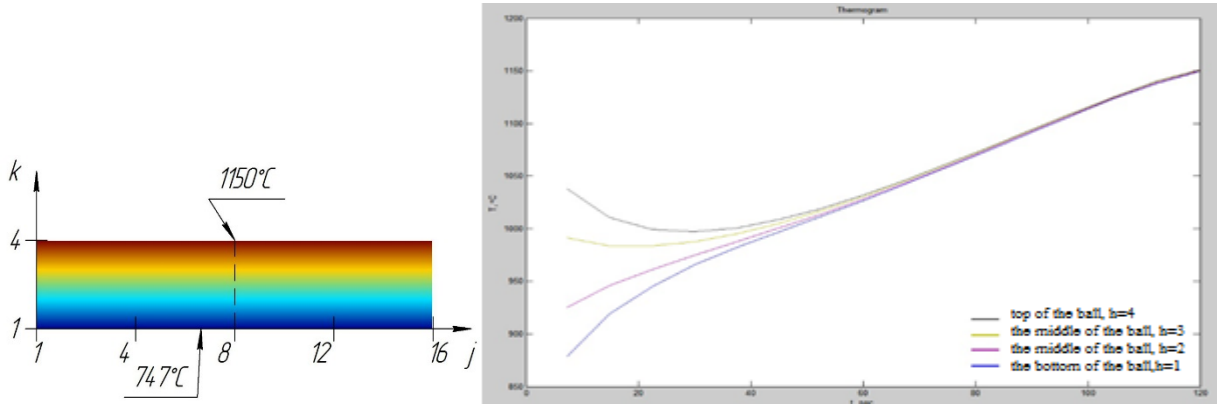
Presentation of the material and results. Using the model and methodology provided for the study of temperature distribution along the height of the layer of pellets, let us define the area of pellets as a three-dimensional array of size [*a*, *b*, *h*], where the column has the dimension [*1*, *1*, *h*] and is located in the middle of conveyor belt width *b* [11]. Depending on the speed of conveyor belt, position of selected for the study vertical column is gradually shifting towards the *x* from the beginning to the end of gas chamber. Tracing time dependence of the temperature of each component unit of pellets within the selected column on the height of its location let us build temperature distribution graph. To do this, let us use the settings for modeling, which are given in Table 1.

Table 1. Parameters of the model for building graph of change over time of temperature distribution along the height of the layer of pellets

Name of parameter	Numeric value	Purpose
a	16	The length of investigated area of pellets layer, the number of indivisible units
b	16	The width of investigated area of pellets layer, the number of indivisible units
h	4	The height of investigated area of pellets layer, the number of indivisible units
dt	0,1	Sampling interval, C
c	897	Specific heat layer pellets, J / kg K
m	15	The weight of the block layer of composite pellets, kg
NL	0,065	The cost of natural gas on the left burner m^3 / s
NR	0,065	The cost of natural gas on the right burner m^3 / s
ke	0,5	Factor that determines how much of the total heat of combustion of fuel consumed in heating the pellets in the areas of direct influence of burners
km	0,5	Factor that determines how much of the total heat of combustion of fuel consumed in all common heating of pellets
q	31788000	Heat of combustion of natural gas, J / m^3

$edge\_a$	20	Shift to the left and to the right from boundaries of [a,:, h] and [1,:, h] section layer pellets before the direct impact zone burners, % from the length of a layer b
$edge\_b$	15	Distances from boundary of [: 1, h and [: b, h] section layer pellets, on which there extended on each side an impact of burners% of the width of the layer b
T_s	275	Temperature of the gas at the exit of smoke chamber, K
T_a	480	Temperature of air supplied to the burner pre-chambers, K
CO	11,7	Concentration of carbon dioxide in dry smoke,% by volume
dx	0,1875	The length of the edges of each constituent element is of cubic form, into which the investigated area of pellets layer is devided, m
L	0,662	Thermal conductivity of pellets layer, W / m K
A	0,8	Ratio, which blocks the absorption properties of the surface layer of pellets and determine the ratio between the number of incident and absorbed heat radiation
V	0,025	Velocity of conveyor belt, m / s
$T\min$	1150	Minimum temperature of the surface layer of pellets while modeling of its initial heating, ○ C
$T\max$	1151	Maximum temperature of the surface layer of pellets while modeling of its initial heating, ○ C
W	50	Width of zone in the surface layer of pellets at a temperature of (Tmax + Tmin) / 2 and Tmax% of the value of variable b
$shft$	0	Offset position of the maximum temperature in the middle of conveyor belt when setting the initial heating of pellets layer % of the value of the variable b (-50% - the leftmost position, 50% - far right position, 0% - middle of the conveyor belt)
dT_h	35	The level of temperature reduction on the bottom line of the component blocks of pellets layer in modeling of its initial heating% of the value of the variable Tmin
CO_2	0,1	Volume percent of carbon dioxide in the fuel
H_2	0,5	Volume percent of hydrogen in natural gas
H_2S	0,6	Volume percent of hydrogen sulfide in natural gas
CH_4	93	Volume percent of methane in natural gas
C_2H_6	3,9	Surround percentage of ethane in natural gas
C_3H_8	1,1	Surround percentage of propane to natural gas
C_4H_{10}	0,4	Surround percentage of butane in natural gas
O_2	0,4	Surround the percentage of oxygen in natural gas

Initial heating pellets in CRM are selected as uniform with temperature on the surface 1150°C. Vertical section of the initial heating of pellets layer on CRM is shown in Fig. 1a, and as a graph of temperature distribution in time along the height of the layer of pellets in the gas chamber within the study - in Figure 1, b.



а) б)

Figure 1. Vertical section of the initial pellet heating layer (a) and a graph of time-temperature distribution along the height of the layer of pellets within the investigated gas-chamber (b)

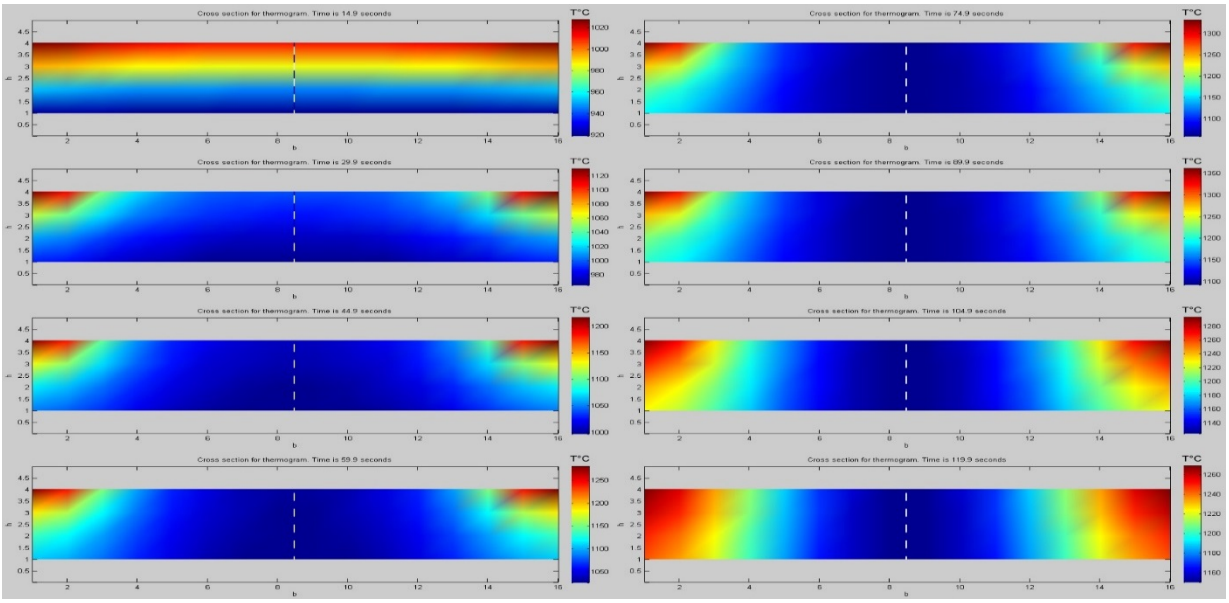


Figure 2. Vertical cross section of the pellets layer at different points of time (position of investigated column is indicated with dashed line)

Conclusions

The main direction of improvement of developed model is to choose the usage of pulsed operation of burners as one of the most prospective for today. Investigation of heat transfer process in bed of pellets allows developing SAR, which will operate not point temperature, measured in certain positions, but the temperature distribution in the whole control object. In such systems, it is advisable to use thermal imaging pyrometer or group that will determine the temperature field of the surface layer of pellets. This innovation will allow for separate control of each of the burners of CRM according to read temperature field of the surface layer of pellets. Using heat transfer model, it is possible to predict changes in temperature of control object basing on the values of current natural gas consumption for each of the burners, which will allow to use fuel more optimally compact.

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