MATHEMATICAL MODEL COOLING AGGLOMERATION FERROUS IN LAYER

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ABSTRACT

Mathematical model is based on discretization agglomeration areas layer deposited on very small. The τ Δ cooling time and the elements of space and elements xi time relationship is discretization as volume control. Based on the mathematical model was presented a program for simulation agglomerates ferrous cooling. The developed program provides the possibilities for the calculation of parameters of air cooler agglomeration.

KEYWORDS: agglomeration, cooling, mathematical model

1. Introduction

Mathematical modeling of physical processes and technology aims to simulate these processes on the computer, and to rich final optimization processes.

Cooling processes accompanied by phase transformations generating tensions between phases frequently met in the process of cooling the ferrous agglomeration. It is therefore necessary to develop three dimensional image applications using simulation calculations and computer graphics, with which endangered areas can be diagnosed.

Cooling agglomeration is a thermo-physical process based on the laws of heat transmission between elements of the cooler. The first step is always a thermal calculation, in which data on the conditions of cooling and other elements of the primary cooling. Results of the calculations give a precise allocation of fixed temperatures cooled material.

In general, this method depending on how to solve the differential equations of complex heat transmission, uses finite differences or finite elements method.

It is based on finite element models that are calculated expansions and tensions arising piece agglomeration. In this way can be localized critical areas in terms of cracks and cooling can be improved.

It is proposed to deal with themes from the heat of a mathematical modeling process of cooling linear agglomeration on which method to use finite differences.

2. Assumptions on the basis of thermal modeling preparation

2.1. Fundamentals of modeling

Material deposited on the whole linear cooling is considered as consisting of a number of variables "z" parallel zones which make up the height of layer deposited on cooling. Each area corresponds to an element of the total material deposited on the cooler being discredited N_{sj}(j=1…z) layer thickness x_j, chosen by the user program.

2.2. Simplifying assumptions

Mathematical model takes into account the following assumptions:

- layer is considered homogeneous, with an equivalent thermal conductivity and a temperature equal to the entire initial mass;
- discretization contact between the layers deposited throughout the cooling process of cooling is fine.
- transmission of heat within the layer takes place primarily by forced convection, heat transfer by conduction in granular materials taking into account a coefficient of conductivity substitution.
- it neglects processes of oxidation, combustion of coke left, or loss of heat and mass training of fine dust particles in the atmosphere;
- it takes account of specific heat changes and thermal conductivity with temperature.

3. Mathematical model equations

Mathematical model is based discretization agglomeration areas layer deposited on cooling time and the elements of space x_i and elements time $\tau\Delta$ very small. The relationship is discretization as volume control. It is used for congested characteristic diagram enthalpy - temperature, because during the calculation to deduct novel temperatures of enthalpy. Thus we can calculate the enthalpy of temperature data fields.

Accuracy depends on the reliability of the thermo-physical quantities introduced as initial data. The accuracy of calculation and simulation is, the greater the discretization space and time is fine. As a result is obtained, the temperature fields and the position represented graphically points inside the layer the temperature has reached a predetermined value.

Mathematical model based on heat transfer between the layers and layer discretization combined depending on the temperatures and thermo-physical characteristics of the layers at the end of the previous time. By thermal analysis processes to determine agglomeration cooling temperatures according to primary and secondary cooling. Calculation of temperature fields is closely related to the geometry of the interior stages. The exchange of heat between layers agglomeration is described by the relationship of heat transport (conduction):

$$\frac{1}{a}\cdot\frac{\partial T}{\partial \tau} = \nabla^2 \cdot T + \frac{q_v}{\lambda} \tag{1}$$

or:

$$\rho_i^k \cdot \left(\frac{\partial H}{\partial \tau_k} + v_r \frac{\partial H}{\partial z}\right) = \mathrm{div}\left(\lambda \cdot \mathrm{grad} \cdot T_i^k\right) \tag{1.1}$$

Exchange of heat between the air cooling and buried layers is described by the relationship:

$$\alpha_{ai}^k = C \frac{\lambda}{d_p^{1-n}} \left(\frac{w_{ar}}{\nu_a}\right)^n \tag{2}$$

where:

- v_c - cooling average speed of the z direction;
- z - coordinates the direction of advancement of cooling agglomeration,
- w_r - relative speed of movement through the air layer, [m/s];
- ν - kinematics viscosity of air, [m^2/s];
- d_p - average diameter pieces agglomeration;
- C, n - constant coefficients determined experimentally.

Relationship (1.1) comes from an energy balance applied to an element volume and describes exactly the three-dimensional heat transfer, if data on the materials are known to be sufficiently accurate.

This should be complemented by the conditions in marginal areas agglomeration.

The degree of confidence of using a calculation model is determined, inter alia by the accuracy with which may be represented by the cooling conditions. Where appropriate, the transfer relationship can be simplified by neglecting certain terms.

Average density of layer "i" at a τ_k time is calculated by the relationship:

$$\rho_i^k = \rho_0 \frac{T_0}{T_i^k} \tag{3}$$

Coefficient of low thermal conductivity layers and valid when they are partially cooled to calculate what the relationship:

$$\lambda_i^k = \lambda_0 \cdot \frac{T_i^k}{T_0} \tag{4}$$

The coefficient of heat exchange between two adjacent layers is given by the relationship (for i = 1 at i = N+1):

$$\alpha_{i,i+1}^k = \frac{1}{\dfrac{x_i}{2\lambda_i^k} + \dfrac{x_{i+1}}{2\lambda_{i+1}^k}}, \tag{5}$$

Values $\alpha_{0,1}^k$ and $\alpha_{N,N+1}^k$ are introduced as the initial data provided by the user as a function of temperature:

$$\alpha_{0,1}^k = f_{a,o}\left(T_0^k, T_1^k\right); \alpha_{N,N+1}^k = f_{a,N}\left(T_N^k, T_{N+1}^k\right) \tag{6}$$

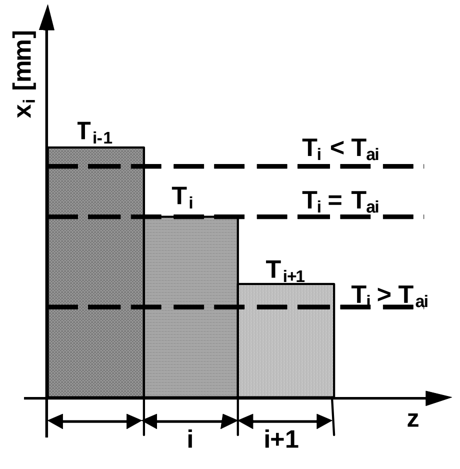

Fig 1. *Air temperature insufflates the layer.*

The three positions differ in position momentary temperature T_i at the layer "i" examined in relation to temperature cooling currently T_{ai}

Assuming that at the time τ_k agglomeration fraction is cooled ξ_1^k, depending $\Delta\tau$ fraction is cooled and the end of time ξ_1^{k+1} on the initial balance equation is:

$$\Delta Q_i^k = \left[\alpha_{i-1,j}^k\left(T_i^k - T_{i-1}^k\right) + \alpha_{i,j+1}^k\left(T_1^k - T_{j+1}^k\right)\right]\Delta\tau - \\ - \alpha_{ai}^k\left(T_i^k - T_{ai}\right) \tag{7}$$

Material granular fraction (agglomeration) when cooled at the time τ_k layer i is given by the relationship:

$$\xi_i^k = \frac{[\alpha_{i-1,i}^k\left(T_i^k - T_{i-1}^k\right) + \alpha_{i,i+1}^k\left(T_i^k - T_{i+1}\right)]\Delta\tau - \alpha_{ai}^k\left(T_i^k - T_{ai}\right)}{x_i \cdot c_i^k \cdot \rho_i^k} \tag{8}$$

so:

$$\xi_i^{k+1} = \frac{[\alpha_{i-1,i}^k\left(T_i^k - T_{i-1}^k\right) + \alpha_{i,i+1}^k\left(T_i^k - T_{i+1}^k\right)]\Delta\tau}{x_i \cdot c_i^k \rho_i^k} + \xi_i^k \tag{9}$$

If ξ_i^{k+1} is not converged in the range [0, 1], then the calculated temperature final layer "i" is reviewed with the following relationship:

$$T_i^{k+1} = T_i^k - \frac{\Delta Q_i^k}{x_i \rho_i^k c_i^k} = T_i^k - \\ - \frac{\left[\alpha_{i-1,i}^k\left(T_i^k - T_{i-1}^k\right) + \alpha_{i,i+1}\left(T_i^k - T_{i+1}^k\right)\right]\Delta\tau - \alpha_{ai}^k\left(T_i^k - T_{ai}\right)}{x_i \rho_i^k c_i^k} \tag{10}$$

In case of fig.2b using the relationship:

$$T_i^{k+1} = T_i^k - \frac{\left[\alpha_{i-1,i}^k\left(T_i^k - T_{i-1}^k\right) + \alpha_{i,i+1}^k\left(T_i^k - T_{i+1}^k\right)\right]\Delta\tau}{x_i \rho_i^k c_i^k} + \\ + \frac{\alpha_{ai}^k\left(T_i^k - T_{ai}\right)}{c_i^k} \tag{11}$$

4. Application model

Based on the mathematical model presented was a computer program for simulation study agglomeration ferrous cooling. The program developed provides the following possibilities:

- it can study and plot the time variation of temperature in any layer (format) on the height of material deposited on cooling;
- may be set during the cooling of noise at any point from the cooler agglomeration;
- can determine the position of points inside the layer when the temperature has reached a predetermined value;
- can study and plot the temperature distribution width cooler at a time;

It can track a crowded crossing in the cooling time or the equivalent, in the direction of travel.

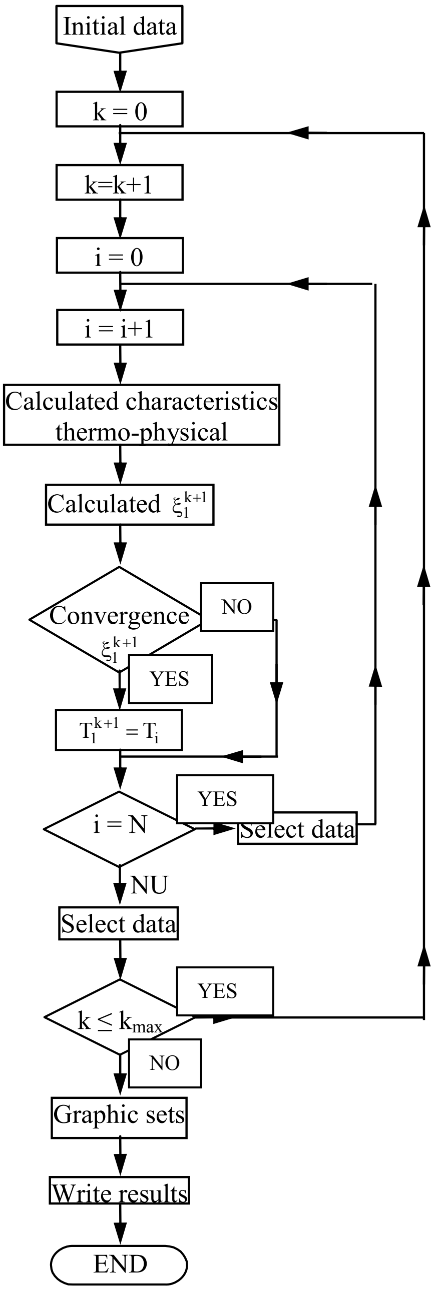

***Fig. 2.** Logic diagram of the cooling agglomerate*

5. Results obtained

Based on the mathematical model presented it was created a computer simulation program for studying agglomeration ferrous cooling.

With this, the density of heat flow exhaust unit is expressed in terms of feature blowing air, as follows:

$$q = \alpha_{ai}^k \cdot \left(T_i^k - T_{0a}\right) \tag{12}$$

Other conditions have been marginal compared to other parts of the surface noise. To describe the heat discharge into the atmosphere has established empirical relationships. Evacuation to heat carts often modeled with an index of transmission of heat having the shape of the relationship (12) is usable on a length of contact.

Calculations were carried out with a large enough number of data fields. To decrease the duration of the calculations is usually accepted the hypothesis that the transport of heat conductivity in the direction "z" (in the horizontal direction in the sense of movement cooling) is negligible compared to the transport of heat by convection and conduction in the direction perpendicular to the layer (output air) and that the process is in stationary state. Under these assumptions, to an agglomeration position on the direction of the exit time τ and z are linked by the relationship $z = v_r \cdot \Delta\tau$. It can track an agglomeration crossing in the cooling time or the equivalent, in the direction of travel.

Mathematical program is complemented with a graphical program that allows tracing of the temperature curves of the type: $T^k = f(x_i)$ or $T_i = f(\tau_k)$. Cooling curves for a total crowded with $T_{initial} = 800\ ^0C$ and $T_{final} = 86\ ^0C$ are shown in figure 3. Results graphic process cooling agglomeration (depending on overall height a end length).

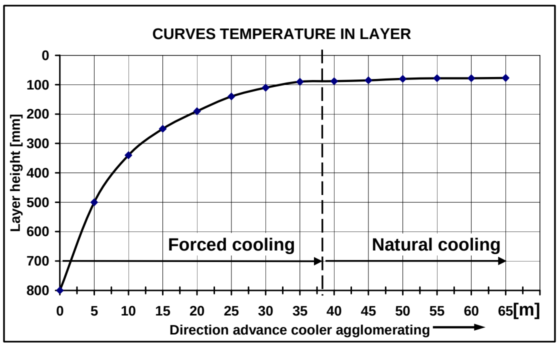

***Fig. 3** Curves of temperature distribution*

6. Conclusions

- The installation of cooling agglomeration is a whole in which various operations and processes are grouped into subsystems which can establish a relation based on the flow technology; they are equipped with peripheral devices for measurement and control.
- The heat from the cooling agglomeration, takes place in a system with many components and a small time interval, the noise temperature decreases rapidly from 800 - 900^0C to temperatures of 85 - 90^0C.
- Cooling is achieved by injection of cold air down through the top layer of material, with fans. The speed of cooling is critical to obtain agglomeration quality flow; the blow through cooling can be adjusted depending on the parameters of real operating cooler.
- To review the operation of the cooling of the agglomeration and establish the parameters that characterize the preparation process it is suggested to balance the heat.
- Knowledge of heating elements allows the required balance of flow of cooling air, the characteristics of thermal plants and cooling the quantity of heat entering and leaving the outlines of cooler balance. Based on these, we may act to reduce losses and improve thermal efficiency
- Mathematical model is based discretization agglomeration areas layer deposited on cooling time and the elements of space x_i and elements time $\Delta\tau$ very small. The relationship is discretization as volume control.

The program developed provides the following possibilities for the calculation of parameters of the agglomeration cooler:

- It can study and plot the time variation of temperature in any layer on the height of material deposited on cooling;
- It can study and plot the temperature distribution width cooling at a time;
- It may be set during the cooling of noise at any point from the cooler;
- It can study the influence of technological parameters on the process of cooling from the cooler.

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