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CONFORMITIES TO LAW OF FORMING LAYER FOR POLYDISPERSE PELLET CHARGE ON SINTER BELT

Motion of pellet charge on the loading tray on a sinter belt is accompanied not only by the change of its grain-size composition, but by segregation processes, id est. by the redistribution of charge of different size particles for the most part friable material. The result of this process is formation of local discontinuity with pre-dominance of content for particles of certain factions. The traditional method for analysis of work for loading tray on the basis of factious classification does not allow to educe and analyze appearing heterogeneity in the most part friable material. It results in errors at the calculation for action of the system of the automated control by sintering process and ignoring of notational of the use of segregation of particles of friable material for optimization of technological process. The use of balance method enables to specify and spread understanding of mechanism of processes which take place during motion of pellet charge in relation to the loading tray, and also to form theoretical pre-conditions for the choice of the rational modes of operations of agglomeration separation of sintering plant. It is set that at monotonous increase of angle of slope for loading tray the segregation phenomena increase in a pellet charge, and after achievement of the defined value – go down, id est. have extreme character. Mentioned features of forming of layer for polydisperse material in the conditions of inconstancy of mechanical properties of its separate factions it is possible to take into account at the use of balance of grain-size composition of charge, loaded on a sinter belt, and charge, being on it, when conditional middle diameters of particles of their components must be equal. On the basis of the set conformities to law of forming of friable of structure of layer the method of authentication of grain-size compositions of pellet charge mixture is in theory reasonable in every its horizon taking into account a segregation during loading.

Keywords: sinter belt pellet charge forming of charge layer, method of modeling, authentication of its grain-size distribution

Introduction. Motion of pellet charge on the highway of loading on a sinter belt is accompanied by both changes of its grain-size distribution and processes of segregation, by the redistribution particles of different sizes in material. The result of such process is formation of local heterogeneity with majority of certain faction's content particles. The traditional method of analysis of loading sinter belts on the basis of factious dispersion does not allow to educe and analyze formed heterogeneities in-bulk friable material. It results in errors during the calculations of parameters of the system of the automated sintering process control action and ignoring of the use of process of segregation for particles of friable material potential for optimization of technological process.

Analysis of publications. In work [1] the quantitative estimation of possibility of intensification of sintering is executed due to the redistribution of different size charge particles

on the height of layer. It is shown that for sintering mixture gas-penetrability of layer with maximal heterogeneity on a height differs from gas-penetrability of layer of homogeneous structure, loaded without segregation, on 20%. In works [2; 3] also this estimation of influence of segregation on gas-penetrability of layer is performed. According to brought given over of management of layer particles of by sintering mixture a segregation causes the increase of its gas-penetrability in middle on 15%.

Authors of works [4; 5] are assuming that one of advantages of segregation is formation of «bed» from large granules. However, here the origin of heterogeneity of layer of charge is not taken into account on matter and grain-size composition. At the same time some authors [6] consider that segregation is useful only to the defined value, higher than which it's unfavorably operates on the process of sintering.

Authors of work [7] consider that a segregation negatively influences on stability of properties of agglomerate, increasing chemical heterogeneity on the height of layer, and the accumulation of far of quantity of shallow factions (- a 3 mm) in overhead horizons of layer is accompanied by the increase of gas-dynamic resistance of the loaded material.

In a number of cases segregation of charge on size in some longitudinal cut of layer is main reason for decline of agglomerate quality [8]. In such works it is shown, that at diminishing of segregation possible is an increase of homogeneity and improvement of metallurgical properties of agglomerate. In work [6] it is shown that segregation is desirable in absence of the combined heating of charge, as results in equalization of thermal level of process. At presence of the combined heating, when the expense of fuel goes down on 10%, its redistribution is accompanied by the lack of warmth in bottom horizons of layer during sintering.

In works [6; 9] it is directed, that a segregation exists not only on the height of layer but also on the width of sintering carts. The comparative estimation of segregation is executed during loading of charge by drum and oscillation feeders. If in the first time distribution of carbon on the height of layer was approximately even, then in the second time its content in an overhead half of layer laid down 5,21%, and in a bottom half of layer – 2,55%. It allowed substantially to promote the technical and economic indexes of sintering process due to the reduction of fuel expense. The results of experiments showed that gas-penetrability of layer considerably rose at setting of loading tray under an angle which is evened or is near to the corner of natural hay-crop of material.

Descriptions of durability of agglomerate in a great deal depend on conformities to law of preservation of chemical composition and thermal mode of process of sintering on the height of layer. In sintering mixture a gumboil and fuel is saved in faction a 0,3 mm, which is an about 83 % carbon and to 73% oxides of calcium [10]. Therefore, the segregation of charge on grain-size distribution causes segregation on content a fuel and influences on the thermal mode of sintering, and, thus, on durability of agglomerate.

The action of external efforts on the structure of stationary layer of polydisperse friable material investigated in works [11,12]. It is shown that treason of height of layer (contraction) related with the compression of its structure at the action of dilution and vibration of construction of sintering machine.

Thus, as an analysis of literary sources shows, on the conditions of passing of sintering process and high-quality descriptions of agglomerate influences mostly distribution of classes of large particles of polydisperse material in its mass before sintering.

Statement of task. Analytical description of the mentioned process is difficult because of considerable influence of different unpredictable factors on the conditions of motion of stream and co-operate constituents of its particles. Therefore it is appropriate to consider the general theoretical questions of forming of layer structure for polydisperse material and set its main

conformities to law. The task of researches is development of method of authentication of grain-size descriptions of charge in each of horizons of layer on a sinter belt taking into account segregation at loading.

Main part of researches. The use of balance method is possibility at specify and spread understanding of mechanism of processes which take place during motion of pellet charge on the highway of loading, and also gives to create theoretical pre-conditions for the choice of the rational modes of operations of sintering separation of agglomerate plant [13].

It is known that during forming of layer of pellet charge after the action of gravity forces look after the uneven placing its separate factions on a height. Every faction is distributed depending on its mechanical descriptions and conditions of motion. The results of such process in a general view are characterized by the next system of equations:

$$
\begin{aligned}
&\Phi_{11} + \Phi_{21} + ... + \Phi_{k1} = \Phi_{1\Sigma}, \\
&\Phi_{12} + \Phi_{22} + ... + \Phi_{k2} = \Phi_{2\Sigma}, \\
&... \\
&\Phi_{1n} + \Phi_{2n} + ... + \Phi_{kn} = \Phi_{n\Sigma}. \\
&\Phi_{11} + \Phi_{12} + ... + \Phi_{1n} = \Phi_{1}, \\
&\Phi_{21} + \Phi_{22} + ... + \Phi_{2n} = \Phi_{2}, \\
&... \\
&\Phi_{k1} + \Phi_{k2} + ... + \Phi_{kn} = \Phi_{k}. \\
&\Phi_{1\Sigma} + \Phi_{2\Sigma} + ... + \Phi_{n\Sigma} = 100\%, \\
&\Phi_{1} + \Phi_{2} + ... + \Phi_{n} = 100\%,
\end{aligned}
\tag{1}
$$

where Φ_{ij} – an amount of i-th faction in j-th area of layer, %; n – an amount of areas in layer of charge; k – a common amount of factions in j-th area of layer, %.

During motion of pellet charge by a gradient plane in the technological system «a loading tray – a hay-crop of stationary layer of material» separate particles in a stream co-operate with each other, that causes the rejection of conformity to law of their distribution in a layer from dependence which got a calculation way [14].

At values of the loading tray angle of tip, that exceed the angle of natural hay-crop of pellet charge, its large factions ($d_i > 6.0$ mm) accumulate in the bottom part of layer. As a result, the middle diameter of particles of charge in this part of layer will exceed its calculation value. When the angle of tip of loading tray arrives at the angle of friction of shallow faction ($d_i < 3.0$ mm) of pellet charge, fluidity of mobile friable mass grows those results in the decline of her segregation after factious composition. As a result, distribution of pellet charge in relation to the height of layer which is formed is carried out without a substantial segregation which assists maintenance of it initial structure.

At the small values of angle of tip of loading tray, approximately concealment with the angle of natural hay-crop of mass of friable material, part of shallow factions pellet charges which before addicts in the bottom half of layer by the large particles, stays too long in its overhead horizons, that is also accompanied by violation of dependence, got a calculation way. At diminishing of values of angle of tip for loading tray to the value, which answers the angle of hay-crop of large faction, condition of motion of pellet charge change. Mobility of friable mass goes down, that results in treason of mechanism of its motion and decline of segregation of component factions.

Thus, in the process of monotonous increase of angle of tip of loading tray of the phenomenon of segregation in a pellet charge increase, and after achievement of the defined value – go down, id est. have extreme character.

Mentioned features of process of forming of layer of polydisperse material at the conditions of inconstancy of mechanical properties its separate factions it is possible to take into account during the use of balance of grain-size distribution of charge which is loaded on a sinter belt, and charge which is on its, when the middle diameters of particles of their components are conditional must be even.

Pellet charge which enters in knot of loading is characterized by equations

$$\Phi_1 + \Phi_2 + ... + \Phi_n = \Phi_\Sigma,$$
$$d_1 \cdot \Phi_1 + d_2 \cdot \Phi_2 + ... + d_n \cdot \Phi_n = d_{cep} \cdot \Phi_\Sigma, \qquad (2)$$

where Φ_i – content of i-th faction in a pellet charge, %; d_i – a middle diameter of i-th faction of pellet charge, mm; d_{mid} – a middle diameter for particles of pellet charge, mm.

After the modeling of structural treasons can be written as

$$\Phi_1' + \Phi_2' + ... + \Phi_n' = \Phi_\Sigma,$$
$$d_1 \cdot \Phi_1' + d_2 \cdot \Phi_2' + ... + d_n \cdot \Phi_n' = d_{mid} \cdot \Phi_\Sigma, \qquad (3)$$

where Φ_i' – content of i-th faction in a pellet charge after structural treasons, %.

The untaken into account factors of layer structure forming cause appearance of design error

$$\Delta\Phi_1 = \Phi_1 - \Phi_1',$$
$$\Delta\Phi_2 = \Phi_2 - \Phi_2',$$
$$...$$
$$\Delta\Phi_n = \Phi_n - \Phi_n'. \qquad (4)$$

On the whole

$$\sum_{i=1}^{n} \Delta\Phi_i = 0 . \qquad (5)$$

A sign and value Φ_i characterize treason of conformity to law of distribution of i-th faction on the height of layer pellet forming charges. Accepting, that treason of amount of i-th faction on the height of layer of charge has monotonous character, the real values of Φ_i expect.

The analytically put task can be decided only for double-base mixture of friable materials. Initial data for the calculations of parameters of the mentioned mixture:

$$\Phi_{11} + \Phi_{21} = \Phi_{1\Sigma},$$
$$\Phi_{12} + \Phi_{22} = \Phi_{2\Sigma},$$
$$d_1 \cdot \Phi_{11} + d_2 \cdot \Phi_{21} = d_{mid1} \cdot \Phi_{1\Sigma},$$
$$d_1 \cdot \Phi_{12} + d_2 \cdot \Phi_{22} = d_{mid2} \cdot \Phi_{2\Sigma}, \qquad (6)$$
$$\Phi_{11} + \Phi_{12} = \Phi_1,$$
$$\Phi_{21} + \Phi_{22} = \Phi_2.$$

According to the initial conditions of forming of pellet charge layer it is for the actions of gravity forces possible to write down $d_{mid1} < d_{mid2}$.

At the same time condition of equality of sum of middle diameters of charge particles on the set horizons of layer and d_{mid} of all friable mass it is possible to present as

$$d_{mid1} \cdot \Phi_{1\Sigma} + d_{mid2} \cdot \Phi_{2\Sigma} = d_{mid\Sigma} \cdot \Phi_\Sigma . \qquad (7)$$

Accepting, that

$$\Phi_{1\Sigma} = \Phi_{2\Sigma} = 0,5\Phi_\Sigma \qquad (8)$$

we get

$$d_{mid1} + d_{mid2} = 2d_{mid\Sigma} \tag{9}$$

During the analysis of the got correlations situations which are characteristic for the real terms of forming of pellet charge layer take place:

– segregation is absents

$$d_{mid1} = d_{mid2} = d_{mid\Sigma} \tag{10}$$

– there is mionectic segregation

$$d_{mid1} + d_{mid2} < 2d_{mid\Sigma} \tag{11}$$

– there is the increased segregation

$$d_{mid1} + d_{mid2} > 2d_{mid\Sigma} \tag{12}$$

The values of parameter d''_{midl}, which are necessary for the search of the real conditions of segregation, choose on the basis of comparison of results of calculations $d'_{mid\Sigma}$ and initial data $d_{mid\Sigma}$.

If $d_{mid\Sigma} > d'_{mid\Sigma}$, then we diminish the size of parameter d'_{mid2} and increase a value d'_{mid1} in comparing to the calculation sizes. In the case, when $d_{mid\Sigma} < d'_{mid\Sigma}$, we execute a reverse operation, id est. we increase the value of parameter $d_{mid\Sigma} < d'_{mid\Sigma}$ and diminish the size of parameter d''_{midl1}.

The new values of parameter d''_{midl} choose taking into account conditions

$$\begin{aligned} d'_{mid1} + d'_{mid2} &= 2d_{mid\Sigma}, \\ d_1 < d'_{mid1} &< d_{mid\Sigma}, \\ d_2 > d'_{mid2} &> d_{mid\Sigma}. \end{aligned} \tag{13}$$

After the choice of new values d''_{mid1} and d''_{mid2} we execute checking of them for accordance to initial data for every sublayer with the use of dependences

$$\begin{aligned} \Phi'_{11} + \Phi'_{21} &= \Phi_{1\Sigma}, \\ d_1 \cdot \Phi'_{11} + d_2 \cdot \Phi'_{21} &= d''_{cep1} \cdot \Phi_{1\Sigma}. \end{aligned} \tag{14}$$

From equations (8) we determine a value Φ'_{11} and Φ'_{21}

$$\Phi'_{11} = \Phi_{1\Sigma} - \Phi'_{21}. \tag{15}$$

Then

$$d_1 \cdot \left(\Phi_{1\Sigma} - \Phi'_{21} \right) + d_2 \cdot \Phi'_{21} = d''_{mid1} \cdot \Phi_{1\Sigma}. \tag{16}$$

From here

$$\Phi'_{21} = \frac{\Phi_{1\Sigma} \cdot \left(d''_{mid1} - d_1 \right)}{d_2 - d_1}. \tag{17}$$

Like determine the value of Φ_{ij} for second sublayer

$$\begin{aligned} \Phi'_{12} &= \Phi_{2\Sigma} - \Phi'_{22}, \\ \Phi'_{22} &= \frac{\Phi_{2\Sigma} \cdot \left(d''_{mid2} - d_1 \right)}{d_2 - d_1}. \end{aligned} \tag{18}$$

Farther we execute verification of rightness of the chosen sizes of parameters d''_{mid1} and d''_{mid2}. For their adequacies to initial data the sum of separate factions in a layer will answer their content in an initial pellet charge. If such condition is not executed, then carry out correction by treason of values d''_{mid1} and d''_{mid2} in the set direction and repeatedly execute a calculation and verification of their adequacy.

Table 1 – Distribution of middle diameter of particles on the height of layer of pellet charge
for drum and oscillation feeders of PISC «Metallurgical combine «Zaporozhstal»

Feeder	Middle diameter of particles, mm					
	Distance is from the top limit of layer, m					
	0.03	0.10	0.17	0.23	0.30	0.37
Drum						
calculation to correction	3.01	3.81	4.15	4.95	5.72	6.21
calculation after correction	2.35	3.41	4.06	4.94	5.72	6.21
experiment	2.18	3.26	4.05	4.87	5.70	6.29
Oscillation:						
calculation to correction	2.88	3.46	4.12	4.98	5.68	6.25
calculation after correction	3.57	3.99	4.24	4.88	5.26	5.97
experiment	3.81	4.00	4.21	4.86	5.24	6.06

Thus, in the step-by-step mode of calculations we determine values Φ'_{11}, Φ'_{12}, Φ'_{21}, Φ'_{22} which answer initial descriptions of pellet charge. In future we calculate the middle diameters of factions of charge of separate horizons of friable mass into each of areas of layer. As a result, we determine conformity to law of distribution of $d_{mid,i}$ a calculation way on the height of layer, which answers the real terms of its forming. Introduction of correction, which takes into account influence of mechanical properties of friable mass, enables considerably to promote exactness of modeling of process of segregation of pellet charge.

Results of calculations of distribution of particles, which are brought on the height of layer of pellet charge for drum and oscillation feeders at the conditions of PISC «Metallurgical combine «Zaporozhstal», is represented in a table 1. It is set that the value of standard deviation for drum feeder folds 0.271 (without correction) and 0.095 (from correction), and for a vibrofeeder – 0.454 (without correction) and 0.021 (from correction).

The executed researches showed that the mechanism of distribution of mass of charge on the height of layer on the sintering light carts of sintering machine was determined by factious composition of material, that load, and by conformity to law of its segregation, dependence which is characterized

$$d_{j,mid} = f(h_{jc}),\qquad(18)$$

where h_{jc} – a height of layer of pellet charge.

A calculation of distribution of separate factions on the height of charge layer can be executed on the base of experimental data by means of numeral methods, in relation to the concrete conditions of work of loading knots for sintering machines.

Conclusions.

1. Analysis of processes of segregation in factious composition of sintering mixture on the height of layer before sintering is executed.

2. The use of balance method for the analysis of processes which take place during motion of pellet charge in relation to the highway of loading on a sinter belt enables to specify their mechanism and create theoretical pre-conditions for the choice of the rational modes of operations of technological equipment of sintering plants.

3. On the basis of the set conformities to law of forming of structure of layer of friable mass in theory the method of authentication of grain-size descriptions of sintering mixture in every its horizon taking into account a segregation during loading is reasonable.

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FOR POLYDISPERSE PELLET CHARGE ON SINTER BELT

Motion of pellet charge on the loading tray on a sinter belt is accompanied not only by the change of its grain-size composition, but by segregation processes, id est. by the redistribution of charge of different size particles for the most part friable material. The result of this process is formation of local discontinuity with pre-dominance of content for particles of certain factions. The traditional method for analysis of work for loading tray on the basis of factious classification does not allow to educe and analyze appearing heterogeneity in the most part friable material. It results in errors at the calculation for action of the system of the automated control by sintering process and ignoring of notational of the use of segregation of particles of friable material for optimization of technological process. The use of balance method enables to specify and spread understanding of mechanism of processes which take place during motion of pellet charge in relation to the loading tray, and also to form theoretical pre-conditions for the choice of the rational modes of operations of agglomeration separation of sintering plant. It is set that at monotonous increase of angle of slope for loading tray the segregation phenomena increase in a pellet charge, and after achievement of the defined value – go down, id est. have extreme character. Mentioned features of forming of layer for polydisperse material in the conditions of inconstancy of mechanical properties of its separate factions it is possible to take into account at the use of balance of grain-size composition of charge, loaded on a sinter belt, and charge, being on it, when conditional middle diameters of particles of their components must be equal. On the basis of the set conformities to law of forming of friable of structure of layer the method of authentication of grain-size compositions of pellet charge mixture is in theory reasonable in every its horizon taking into account a segregation during loading.

Keywords: sinter belt pellet charge forming of charge layer, method of modeling, authentication of its grain-size distribution