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SECTION 7. Mechanics and mechanical engineering.

MATHEMATICAL MODEL OF CRUSHING OF GRAIN RAW MATERIALS

Abstract: *Relevant problem of technological processes of crushing is reduction of specific expenses of energy (power consumption). And it is the most important for crushers, mills, etc., that is for the cars meaning shock impact on the processed material. One of solutions of this problem is the corresponding preparation of raw materials, in particular preliminary processing by cold.*

In this regard the purpose of our research is development of mathematical model with application of crushing of grain raw materials before crushing process. Creation of mathematical model begins with development of the general technique of a research of process of deep freezing and also a technique of its application. Further theoretical models which serve for determination of internal parameters of process and also features of processing of material when crushing are created. The final stage is development of recommendations for realization of crushing in the conditions of the enterprises of the formula-feed industry.

The conclusion is drawn that freezing leads to change of coefficient of hydraulic resistance to the movement of the blade in an air and vortex layer, and in an air and grocery layer, coefficient of hydraulic resistance of the case of the grinder to rotation of an air and grocery layer and as a result to change of the power going for mixing of an air and grocery layer.

Key words: *crushing, power consumption, grain raw materials, technological process, power, formula-feed industry, mathematical model, resource-saving.*

Language: *English*

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Introduction

Theoretical base are modern ideas of regularities of a heat mass transfer in the course of crushing.

It should be noted that the shock using-up impacts on the crushed product are mechanical. Thus, process of crushing of this look needs to be considered as impact of working body on the processed material by means of mechanical forces. At mechanical crushing a part of energy goes directly for process, and a part on losses to the environment. Effective carrying out process of the shock using-up crushing is connected with transfer of energy consumption towards direct crushing.

For drawing up mathematical model of process of the shock using-up crushing it is expedient to use optimization of an object by method of parametrical synthesis [1,6]. For the purpose of improvement of quality of finished goods and energy saving it is necessary to perform optimization of process in a complex of parameters of effect.

Korotkov V.G., Kishkilev S.V., Antimonov have offered C.B. [2,7] for the mathematical description of process of the shock using-up crushing model of the mechanism of the rotor principle of action with shaft of a rotor which axis is located vertically. Power approach which allows to receive interdependence of energy consumption on crushing and on material destruction makes a basis of the mathematical model offered by the above-stated authors. Application of approach of Korotkov V.G. with coauthors gives initial prerequisites for identification of parameters of process of crushing. Crushing process, both for without sieve [2], and for sieves a grain of crushers [3,8], has been studied when crushing grain, and mathematical models of process which are based on Euler's theorem of the sum of the moments of the closed system [4,9] have been made. At a research of characteristics air layer of the grocery layer which is carried out by a number of authors it is revealed that its density, geometrical the sizes of particles, district speed and some other parameters define efficiency of process of crushing [5,10].

We will consider the movement of a product in grinders of centrifugal type.

In Kobylkin D.S. works with coauthors the working zone of the crusher is presented in the form of the space combining air layer - a vortex zone and air layer a grocery layer [5]. And it should be noted that air layer - the vortex zone in the place of contact with air layer - a grocery layer has a pronounced dividing surface which arrangement is defined by the district speed of a rotor, density air layer - a grocery layer and the geometrical sizes of separate particles.

The scheme of decomposition of working bodies of the vertical rotor crusher is provided on the figure 1.

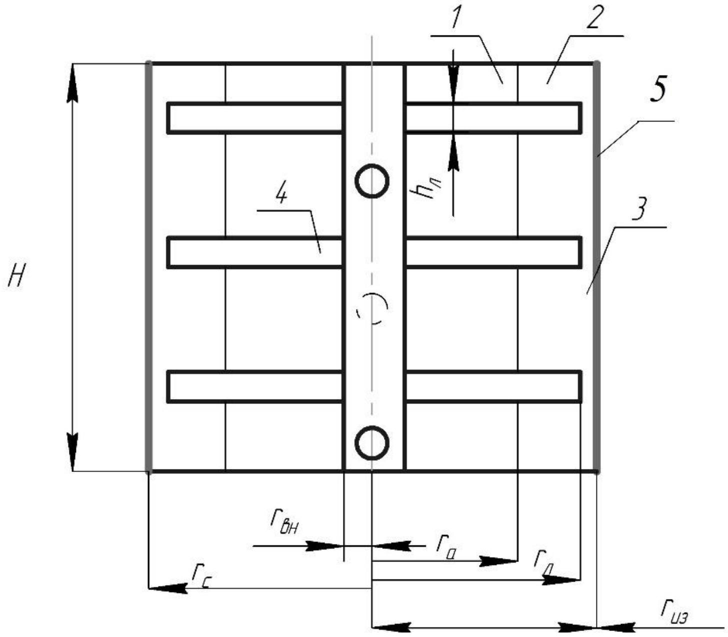

Figure 1 – Crusher. 1 – an air and vortex zone, 2 – an air and grocery layer, 3 – air layer a grocery layer on the site between working body, 5 – the feed well.

The previous researchers ignored the material transformations happening on site 3. Besides in the mathematical models developed by them the capacities spent for mixing air layer – a grocery layer on sites 2 and 3 weren't considered.

The uniqueness of the offered approach to development of mathematical model of crushing is that by her drawing up forces going for mixing air layer - a grocery layer on sites 2 and 3 have been for the first time considered.

Power which is spent for work of useful forces can be determined from balance of capacities which can be presented in the form:

$$N_2 + N_a = N_c + N_{из} + N_{2сл} + N_{3сл}, \qquad (1)$$

where N_2 - the power transferred by a rotor directly air grocery to a layer, W/kg;

N_a - the power transmitted through border of an air and grocery layer and air and vortex zone, W/kg;;

N_c - the power allocated by an air and grocery layer at friction about a wall of the working camera of the grinder, W/kg;

$N_{из}$ - the power spent for processes of crushing, W/kg;

N_{2cl} - the power going for mixing air layer of a grocery layer on site 2, W/kg;

N_{3cl} - the power going for mixing air layer of a grocery layer on site 3, W/kg.

Capacities of Na and Nc are supposed to be calculated by formulas the received Kobylkin D.S. with coauthors [5].

For calculation of capacities of N2; N_{2cl} and N_{3cl} is used the technique offered by Antimonovy C.B.[2], based on representation of the specified district speed air layer - a vortex zone and in air layer – a grocery layer in the form of a polynom of the fourth degree from distance from a crusher axis. At the same time further are analytically removed consistently: dependences for the moments of resistance of the environment and according to capacities of the working bodies of the crusher spent for resistance to action.

The power transferred by the crusher directly air grocery to a layer is equal:

$$N_2 = z_л \xi_{2л} h_л \frac{\rho_c \omega_0^3 r_a^3}{2}\left(\frac{\psi_1^2(1-\bar{r}_{вн}^8)}{8}+\frac{2\psi_1\psi_2(1-\bar{r}_{вн}^7)}{7}+\frac{\psi_2^2(1-\bar{r}_{вн}^6)}{6}-\right.$$
$$\left.-\frac{\psi_1(1-5\bar{r}_{вн}^6)+6\bar{r}_{вн}^5(1+\psi_1)}{15}+\frac{2\bar{r}_{вн}^2(4\bar{r}_{вн}+3)+1}{12}\right) \quad (2)$$

The power going for mixing air layer - a grocery layer on site 2 is equal:

$$N_{2сл} = \xi_{сл}\cdot\rho_c\cdot\omega_0^3\cdot r_a^2\left(\pi H r_a\cdot\left(\frac{\psi_1^2\cdot\left(\bar{r}_л^{-9}-1\right)}{9}+\frac{\psi_1\cdot\psi_2\left(\bar{r}_л^{-8}-1\right)}{4}+\frac{\psi_2\left(\bar{r}_л^{-7}-1\right)}{7}+\frac{\psi_1\cdot\left(\bar{r}_л^{-6}-1\right)}{3}+\right.\right.$$
$$\left.\left.+\frac{2\psi_2\left(\bar{r}_л^{-5}-1\right)}{5}+\frac{\bar{r}_л^{-3}-1}{3}-\frac{z_л-F_л}{2}\times\left(\frac{\psi_1^2\cdot\left(\bar{r}_л^{-6}-1\right)}{8}+\frac{2\psi_1\psi_2\left(\bar{r}_л^{-7}-1\right)}{7}+\frac{\psi_2\left(\bar{r}_л^{-6}-1\right)}{6}+\frac{2\psi_1\left(\bar{r}_л^{-5}-1\right)}{5}+\frac{\psi_2\left(\bar{r}_л^{-4}-1\right)}{2}+\frac{\bar{r}_л^{-2}-1}{2}\right)\right)\right) \quad (3)$$

The power going for mixing air layer of a grocery layer on site 3 is equal:

$$N_{3сл} = \xi_{сл}\cdot\rho_c\cdot H\cdot\omega_0^3\cdot r_a^2\left(\frac{\psi_1\cdot\left(\bar{r}_c^{-10}-\bar{r}_л^{-10}\right)}{10}+\frac{2\psi_1\cdot\psi_2\left(\bar{r}_c^{-9}-\bar{r}_л^{-9}\right)}{9}+\frac{\psi_2\left(\bar{r}_c^{-8}-\bar{r}_л^{-8}\right)}{8}+\frac{2\psi_1\cdot\psi_2\left(\bar{r}_c^{-7}-\bar{r}_л^{-7}\right)}{7}+\frac{\psi_2\left(\bar{r}_c^{-6}-\bar{r}_л^{-6}\right)}{3}+\frac{\bar{r}_c^{-4}-\bar{r}_л^{-4}}{4}\right) \quad (4)$$

We will receive the equation for the power spent directly for crushing from the equation (1)

$$N_{из} = N_c + N_{2сл} + N_{3сл} - N_2 - N_a \quad (5)$$

or check of compliance of experimental data to settlement the semi-industrial experiment by determination of dependence of specific expenses of energy on temperature of the crushed material 0C has been made.

The similar settlement dependence is received with use of the equations 2,3,4,5 and the equations

$$W_{уд} = \frac{N - N_{xx}}{Q_T} \quad (6)$$

where N – the power of process of crushing, W;

Nxx – electric motor power idling crushers, W;

QT – the technological productivity of process of crushing, kg/h.

The comparative analysis of dependences submitted in the figure 2 shows that the divergence between experimental and settlement data doesn't exceed 5%.

Conclusion

Thus, the power spent for crushing generally depends from: the power transferred by a rotor direct air grocery to a layer, power of the working camera of the grinder, power spent for mixing vozdushno allocated by an air and grocery layer at friction about a wall - a grocery layer.

Cooling of the crushed material (zernosmesa) up to the temperature 0C gives to considerable decrease in energy consumption on carrying out process of crushing below.

The comparative analysis of settlement and experimental dependences of specific costs of energy of implementation of process on temperature of the crushed material confirms an opportunity of application of the had mathematical model for calculation of power parameters when developing a design of crushers since the rejection of eksperementalny data from settlement doesn't exceed 5%.

In further researches it is planned to perform on the basis of mathematical model optimization of process of crushing on power indicators and to develop recommendations for practical use at the enterprises for production of forages and feed additives.

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