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OPTIMIZING THE ENERGY CONSUMPTION TO MOULDS OF PALLETING MACHINES OF MIXED FODDERS

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Abstract: *This paper aims to analyse the development of technological works of granules production from concentrate fodders and to insist upon the physical-mechanical principle of their achievement. The proposed mathematical model has few simplifying assumptions, which is why it can be used for the rational sizing of moulds of pelleting machines. The methodology of approach of this topic can be expanded with specific elements and also for granulation, and respectively for briquetting the fibrous fodders.*
Keywords: *moulds, granulation, mixed fodders*

1. GENERAL CONSIDERATIONS

Granulation is the process of pressing of concentrated mixed fodders, of vitamins, of bioenergizers etc, in order to obtain some fodders with a high content of nutritive substances.
Granulation allows the increase of the mechanization and automation degree of the feeding process, with an important disposal of the dissipation.
The most important advantages of this process are:

- rational use of resources;
- the decreasing of storage by increasing its density;
- a high homogenization of the composition;
- a natural repose angle, with positive effects of the flow through the plant ducts of food distribution;
- also allows the air circulation through granules during storage;
- and do not make possible for animals to choose in a preferential way the components of the fodders.

The granulation process involves a series requirements, among the basic ones we mentioned:

- the ones which does not modified the organoleptic properties of fodders;
- those which realise granules with a high mechanical resistance and a low friability;
- the granules sizes should match with the zootechnical and biological needs of animals to which they are for.

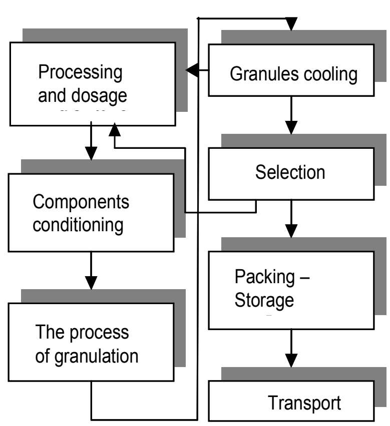


Figure 1: Block pattern of the technological process of fodders granulation

The conditioning of raw materials consists of shredding and of dosing the components in parallel with the adjustment of working temperature and it is carried out with the following purposes:

- particles agglomeration (with steam or sticker addition);
- the increase of mechanical resistance;
- an easy decomposition to digestion;
- the correlation of friction forces to pressing;
- the decrease of the sticker effects of the working to pressing.

The block pattern of the technological process is shown in Figure 1.

The marked returns indicates the bringing back of crushed grains or of those which do not have the requirements imposed in the processing sector, and they are once again placed on the stream.

We can se that the granulation still presents some technological difficulties, additional costs related to the investments in plants and high energy consumptions. However these difficulties are attenuated through the advantages presented at the beginning of the work.

2. THE MATHEMATICAL MODEL OF THE COMPRESSION PROCESS

The fodders pressing essentially represents their density increase, by raising up the pressure which acts upon them. The experimental researches show that the variation of pressure depending on density can be expressed as a relation under the form of [2]:

$$p = C \cdot \rho^{m} \tag{1}$$

where C and m represents the dependent coefficients of the material subjected to compression and ρ- the specific mass.

This variation is represented in Figure 2, and it can be touched by fodders humidity. It was observed that the pressing needed to granulation decrease at the same time with the increase of the humidity.

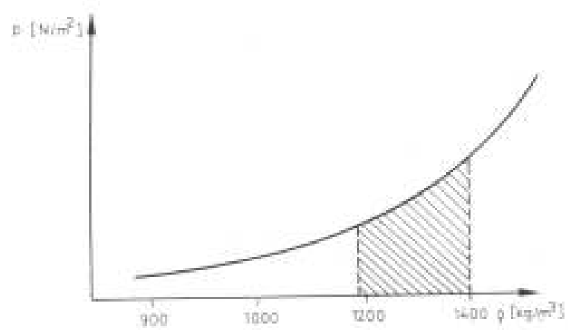


Figure 2: The change of granules density depending on the working pressing [2]

The physical principles of the granulation process with the symbolical representation of the active working organs are shown in Table 1.

Regardless the form of pressing chambers, during working, there are forming friction forces with sides. They

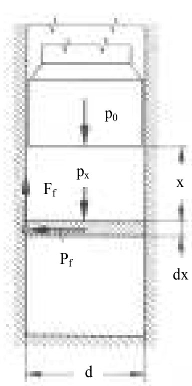


Figure 3: The physical model of pressing chamber

change the pressure in the direction of compression and the one perpendicular to it.

The mathematical model proposed is based upon the simplifying assumption of a cylindrical pressing chamber with inner diameter d, as shown in Figure 3.

It is considered that at the current distance x, the friction pressure p_f, perpendicular to the motion direction is constant. If you take an elementary volume of a cylindrical shape with the height dx and pressure given by the working organ p_0, we can write the equilibrium equation of forces after axial direction of motion:

$$\frac{\pi \cdot d^2}{4} \cdot dp_x + \mu \cdot \frac{\nu}{1-\nu} \pi \cdot p_x \cdot dx = 0 ; \qquad (2)$$

where: p_x represents the the pressing on the elementary conssidered surface; μ - the friction coefficient with the inner walls and ν - Poisson coeffient.

After simplification and separation of variables it results the following differential equation:

$$\frac{dp_x}{p_x} = -\mu \cdot \frac{\nu}{1-\nu} \cdot \frac{4}{d} \cdot dx \qquad (3)$$

After the integration between the variables limits p_0-p_x , respectively 0 – x we obtained:

$$ln \frac{p_x}{p_0} = -\mu \cdot \frac{\nu}{1-\nu} \cdot \frac{4}{d} \cdot x , \qquad (4)$$

which after the logarithmation is transformed into:

$$p_x = p_0 \cdot e^{-\mu \cdot \frac{\nu}{1-\nu} \cdot \frac{4}{d} \cdot x} \qquad (5)$$

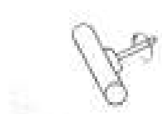
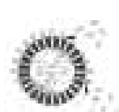
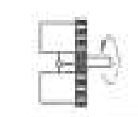
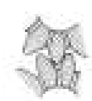
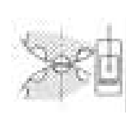
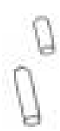
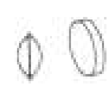
This relation is valid in the case of compression of closed chambers.

Compression, in the case of granulator with moulds or spiral or with spur, takes place in pressure chambers realised under the shape of some open ducts.

In this case, the pressing forces are balanced on the friction ones between the material and the duct sides. Their size depends on the length of the duct.

If generally the pressure relation (5) is written down with x = l (duct length) and p_x = 1 (atmospherical pressure), results:

Table 1: Physical principles of the granulation process [2]

Granulation by aggregation	Granulation by drawing				Granulation by compression	
	With slug	With annular molds	With plat mold	With spurs	With sectional rollers	With cylindrical chamber
						
						
p=0	p = 10...100MPa				p ≤ 1000 MPa	

$$1 = p_0 \cdot e^{-\mu \cdot \frac{\nu}{1-\nu} \cdot \frac{4}{d} \cdot l} \qquad (6)$$

After logarithmation we can extract the expression of the duct length for which is necessary a pressure p_0:

$$l = \frac{d \cdot (1-\nu) \cdot ln\, p_0}{4 \cdot \mu \cdot \nu} \qquad (7)$$

This relation highlights the fact that the pressure of duct length is proportional with the natural logarithm of pressure.

The determination of power consumed during the pressing process can be realised with the following relation:

$$P_{granulation} = F_f . v_m . n_{cps} , \qquad (8)$$

where: F_f represents the friction force of the material with the sides of the passing ducts; v_m – the average motion velocity of granules and n_{cps} – the number of ducts with simultaneous pressing of the blending.
The variation of friction force is calculated with the expression:

$$F_f = \mu.k.p_0.l_p.l, \tag{9}$$

where k is the coefficient of lateral displacement (k=0,4…0,45) and l_p – the perimeter of the pressing duct.
The average motion velocity of granules is:

$$v_m = \frac{l}{t_g}, \tag{10}$$

where t_g represents the bleeding time which is included between 16 and 18 s.
For the number of ducts pressed simultaneously we can write:

$$n_{cps} = n_c.n_r.\frac{\alpha}{2.\pi}, \tag{11}$$

where n_c represents the total number of the mould ducts, n_r – the number of pressing rollers and α- the central angle of the pressing zone of the roller.

3. THE RUNNING OF THE MATHEMATICAL MODEL AND THE INTERPRETATION OF THE RESULTS

The mathematical model presented above has been rolled out in MATHCAD programme and there were used the following input data: the inner diameter range of the flute compression between 4 and 8 mm, length 25 ...50 mm, friction coefficient of 0.1 and Poisson's ratio of 0.85.
The graph obtained is shown in Figure 4 and represents the working pressure variation which depends on the length and of the diamater of compression duct.

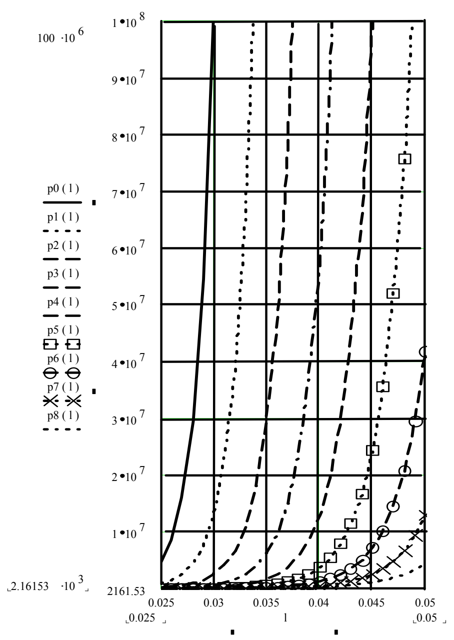


Figure 4: The dependence of the granular pressure depending of the length of the flute

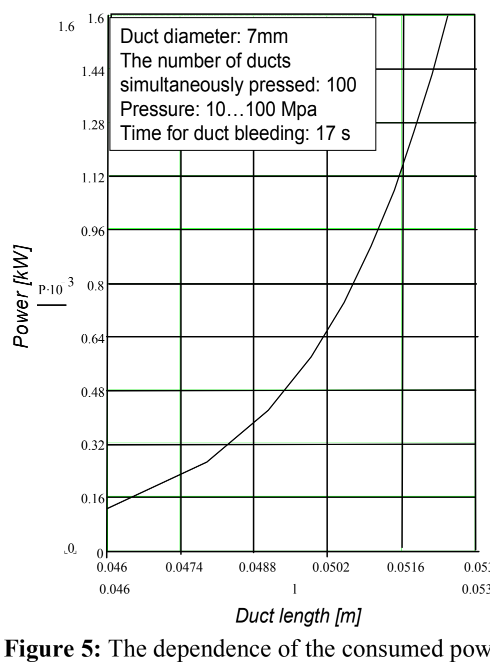


Figure 5: The dependence of the consumed power to granulation depending of the length of the flute

Knowing the variation of the length of the duct depending on pressure, it was studied the power consumption during the compression process, in the case of a hypothetical granulator with the hole diameter of 7 mm.
For this was required a variable pressure from granulation range (of 10 ...100 MPa), depending on which resulted a range of ducts lengths. These have allowed the study of friction varition, and in the end of the consumed power during the process of granulation. The results are graphically shown in Figure 5.

4. CONCLUSIONS

The analysis and modeling of the granular process presented in this paper allows the achievement of some forms and sizes for a wide range of moulds. The way how the process of pressing and making-up the granules makes possible the application of the method described and the sizing of the active elements of the pressing and briqueting equipments.

Thus we cand find an optimum variant between energy consumption, geometric dimensions of the end product and the biological requirements of the animals, the size of granules depending on species and age.

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