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Shape of Pressing Chamber for Wood Biomass Compacting

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Abstract: *The main goal of this contribution is to present results of analyse of mathematical models of wood biomass compacting. Doesn't exist a lot of models which describes real state in pressing chamber and amount of factors impact at compacting process and thereby on briquette quality. According to our suggestion have also constructional parameters of pressing chamber (pressing spout and pressing ram) expressive impact on result briquette quality. We did theoretical analyses which showed us that impact on briquette quality have also change of pressing chamber length, change of friction coefficient, change of pressing chamber conicalness and also change of pressing chamber diameter*

Keywords: *shape of pressing chamber, conicalness of pressing chamber, mathematical model of compacting, briquette quality, compacting pressure*

1. INTRODUCTION

By experience we know that not only technological parameters (compacting pressure, pressing temperature, material humidity and fraction largeness) have impact on result briquette quality however also constructional parameters (pressing chamber length, pressing chamber conicalness, friction coefficient between pressing chamber and pressed material).

The goal of this analyze is to obtain more knowledge about impacts of all constructional parameters on result briquette quality, to obtain knowledge about interaction relations between lonely parameters, which should be the base for optimalisation of compacting process. After these analyses we would like to verify results on our designed experimental pressing stand (Fig. 2 and Fig. 3).

2. MATHEMATICAL MODEL OF COMPACTING

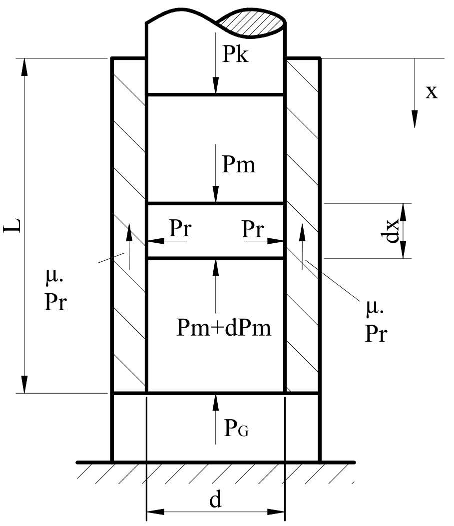
On Fig.1 we can see described pressing process on vertical press. Maximal compacting pressure Pk which is rising by pressing depend on pressing chamber length and shape, depend on friction relations between pressed material and wall of the chamber. Drag friction is backward assigned by radial pressure Pr, applied to chamber wall, by friction largeness μ and pressing chamber length L. Required compacting pressure Pk we are able to obtain with right dimensioning, with construction and with changing of pressing chamber length.
Equation (1) describes Fig.1.

$$\left[Pm - \left(Pm + dPm\right)\right] \cdot \frac{\pi . d^2}{4} - \mu . \Pr . \pi . d . dx = 0 \quad \text{.....(1)}$$

By equation (1) solving and by border conditions substituting we get equation (2).

$$P_k = P_G . e^{\frac{4.\lambda.\mu.L}{d}} \quad \text{.......................................(2)}$$

We analyzed equation (2) and we monitored impact of changing of pressing chamber length and impact of changing of friction coefficient on axial pressure on extrusion (Pm).



P_k – axial pressure of ram [MPa]
P_r – radial pressure [MPa]
P_G – backpressure in pressing chamber [MPa]
P_m – axial pressure on extrusion [MPa]
d – diameter of pressinf chamber [m]
μ – friction coefficent [-]
L – pressing chamber length [m]

Figure 1 – Pressing process on vertical press

3. IMPACT OF PRESSING CHAMBER LENGTH

At analyze of change of pressing chamber length impact we chose as a base value L=140 mm, because in our experimental pressing stand we are limited by construction. We raised this value about 10%. Other parameters we chose according to designed experimental pressing stand.

$$\lambda = \frac{\sigma_r}{\sigma_m} = \frac{P_r}{P_m} \in \langle 0 \div 1 \rangle \Rightarrow choose \rightarrow 0{,}5 \quad (3)$$

μ= 0,35; d= 0,02 m; PG = 1 MPa

$$\alpha = \frac{P_r}{P_k} \cong 0{,}15 \div 0{,}20 \Rightarrow choose \rightarrow 0{,}175 \quad (4)$$

$$\frac{P_r}{P_k} = 0{,}175 \Rightarrow P_r = 0{,}175.P_k \quad \text{................(5)}$$

By substituting (5) into (3) we get equation (6):

$$P_k = 2{,}86.P_m \quad \text{..(6)}$$

By completing of equation (6) into the equation (2) we get equation (7):

$$P_m = \frac{P_G}{2{,}86}.e^{\frac{4.\lambda.\mu.L}{d}} \quad \text{................................(7)}$$

L [mm]	**140**	126	113,4	102	91,8	82
change of L [%]	-	-10	-10	-10	-10	-10
Pm [MPa]	**46,95**	28,77	18,51	12,42	8,7	6,17
change of Pm [%]	-	-38,7	-35,7	-32,9	-29,95	-29

Table 1 – Calculated values for pressing chamber length „L“

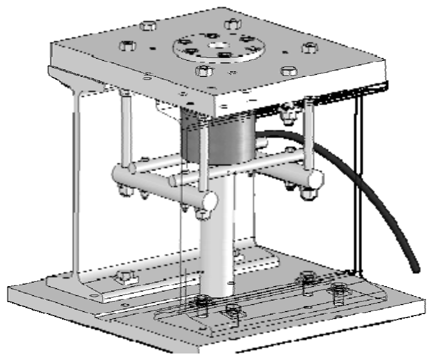


Figure 2 – 3D model of pressing stand

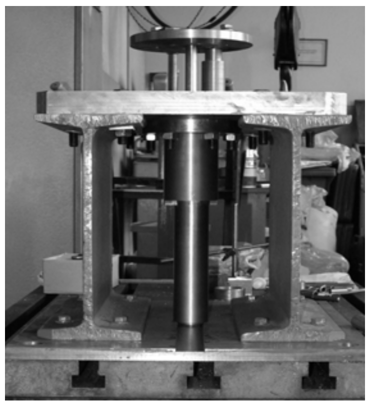


Figure 3 –Experimental pressing stand

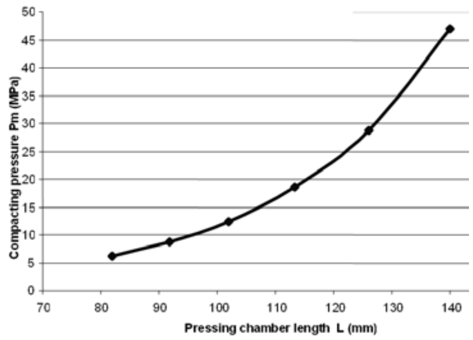


Figure 4 – Dependence of axial pressure on pressing chamber length

Results of this analyze is when we increase pressing chamber length also increase the compacting pressure on extrusion Pm. At enlarging the pressing chamber length about 10% compacting pressure increase average about 33%.

4. IMPACT OF FRICTION COEFFICIENT

At analyze of change of friction coefficient we chose as a base value μ=0, 1. We raised this value about 20% from interval of values <0,1÷0,4>, which is interval of friction coefficient values for steel - wood. Other parameters we chose according to designed experimental pressing stand.

$$\lambda = \frac{\sigma_r}{\sigma_m} = \frac{P_r}{P_m} \in \langle 0 \div 1 \rangle \Rightarrow choose \rightarrow 0{,}5$$

L= 0,14 m; d= 0,02 m; PG = 1 MPa.

At calculation we worked with mathematical model – equation (7).

μ [-]	change of μ [%]	Pm [MPa]	change of Pm [%]
0,1	-	**1,42**	-
0,12	20	1,88	32,4
0,144	20	2,63	40
0,173	20	3,94	50
0,21	20	6,61	68
0,252	20	11,91	80,2
0,3	20	23,32	96
0,36	20	54	131,6
0,432	20	148	174

Table 2 – Calculated values for friction coefficient „μ”

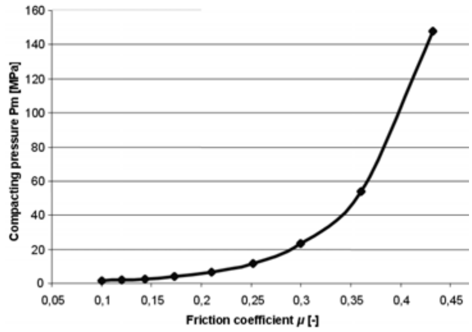


Figure 5 – Dependence of axial pressure on friction coefficient

Result is follow - compacting pressure exponential increase at enlarging the friction coefficient about 20%.

5. IMPACT OF PRESSING CHAMBER DIAMETER

At analyze of change of pressing chamber diameter we chose as a base value d=20 mm. We raised this value about 20% in interval of values <20 ÷ 50 mm>, which is interval is interval values according to designed experimental pressing stand. Other parameters we chose according to designed experimental pressing stand.

$$\lambda = \frac{\sigma_r}{\sigma_m} = \frac{P_r}{P_m} \in \langle 0 \div 1 \rangle \Rightarrow choosen \rightarrow 0{,}5$$

Chosen constant parameters: L=0,14 m; μ=0,35 ; PG = 1 MPa

At calculation we worked with mathematical model – equation (7).

d [mm]	**20**	24	29,8	35,56	42,67
change of d [%]	-	20	20	20	20
Pm [MPa]	**46,95**	21,1	9,5	6,15	3,48
change of Pm [%]	-	55	55	35,3	43,4

Table 3 – Calculated values for pressing chamber diameter „d”

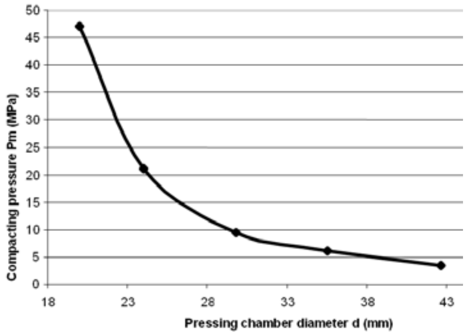


Figure 6 – Dependence of axial pressure on pressing chamber diameter

Result of this analyze was awaited - compacting pressure on extrusion exponential decrease at enlarging of pressing chamber diameter.

6. EXPERIMENTS PREPARING

Results of these analyses show us that pressing chamber length and friction coefficient are parameters which have expressive impact as on compacting pressure so as on overall compacting process and briquette quality. We think that also conicalness of pressing chamber has also great impact on compacting pressure. It is necessary to make experiments in this field and to reach of shape and dimensional optimalisation of pressing chamber and pressing spout. We have to verify results of analyses by experiments. We designed following types of pressing chambers in various dimensional scales.

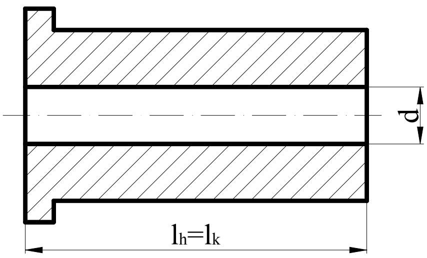


Figure 7 –Pressing chamber with constant diameter and varied length

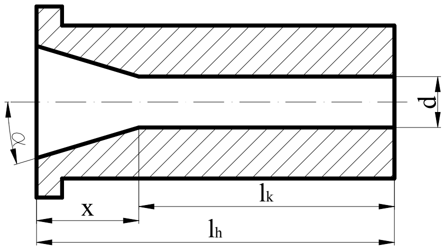


Figure 8 –Pressing chamber with varied length of conic and varied angle of conic

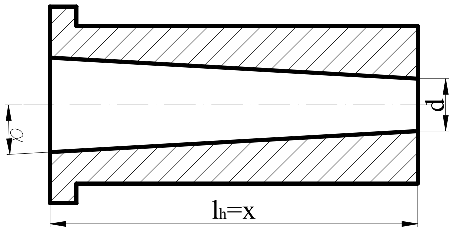


Figure 9 –Pressing chamber with varied angle of conic through full chamber

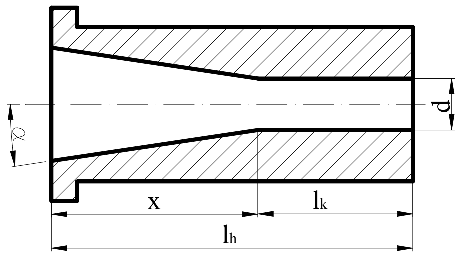


Figure 10 –Pressing chamber with constant length of conic and varied angle of conic

In this time we make this experiments therefore I don't have know results.

7. CONCLUSION

Pressing chambers or pressing spouts are parts of compacting machines which belongs to the group of machine parts which are extreme shabby. Therefore it is necessary to make shape and dimensional optimalisation of pressing chambers from shabby point of view. By decreasing of pressing chambers shabby we increase of result extrusion hour production. But this optimalisation will have impact also on result briquette quality. We try to design those pressing chambers which will be able to work by lower compacting pressures and will produce asked result briquette quality. Conicalness of pressing chamber is advantageous from pressures distribution in chamber point of view. We know that when we use conic shape chamber at the same compacting pressure we are able to produce better quality briquettes as with cylindrical shape of chamber. Impact of pressing chamber conicalness is necessary to verify by experiments in practice on real compacting machines.

- We would like to input results of shape and dimensional optimalisation to the mathematical model which describes compacting process and where is included only some technological parameters till now.

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