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HYDROSTATIC PRESSURE IN THE PROCESS OF WOOD BRIQUETTES COMPACTING

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ABSTRACT: The bulk of the energy is still produced by burning fossil fuels: coal, petroleum products and natural gas. Supplies of these fuels are exhaustible and burning them pollutes the environment. Therefore, it is very important to find sustainable alternatives with lower emissions. The major renewable energy source is biomass, and of it, a significant proportion is constituted of wood waste. It is estimated, that in Slovakia 2.3 million tones of wood waste is produced annually, which represents 72% by weight of biomass, but it is less than 3% of thermal energy production. For the biomass combustion, it is necessary to transform the waste wood into the form of pellets or briquettes via different technologies to form the different shapes. The paper deals with the experiments of compacting wood briquettes made of oak sawdust in the laboratory conditions. For the process of briquetting as well as for the heating properties, the shape of the final product is very important. In the experiment, the characteristics of briquettes shaped according to Drzymal were assessed - the combustion heat and the calorific value.
KEYWORDS: sawdust, woodchips, briquette, pressure, calorific value, combustion heat

INTRODUCTION

The world-wide energy consumption will on average continue to increase by 2% per year. A yearly increase by 2% leads to a doubling of the energy consumption every 35 years. [1] This means the world-wide energy consumption is predicted to be twice as high in the year 2040 compared to today.

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WOOD BRIQUETTES COMPACTING EXPERIMENTS

Wood briquettes are made by pressing wood chips with no binder added. The ideal shape would be a sphere, processed by pressing the woodchips towards the centre of the sphere. In such case, the pressure would be homogenously distributed in the volume of the sphere, but the compacting equipment would be complicated in the point of view of its construction.

For the experiments with oak sawdust pressing without any binder two concave cylindrical forms were selected rotated to each other by 90° (the design according to Drzymal) [4]. The shape of briquettes to some extent mimics the shape of the sphere and pressure distribution is more favorable in comparison with cylindrical shaped briquettes, which is the most widely used.

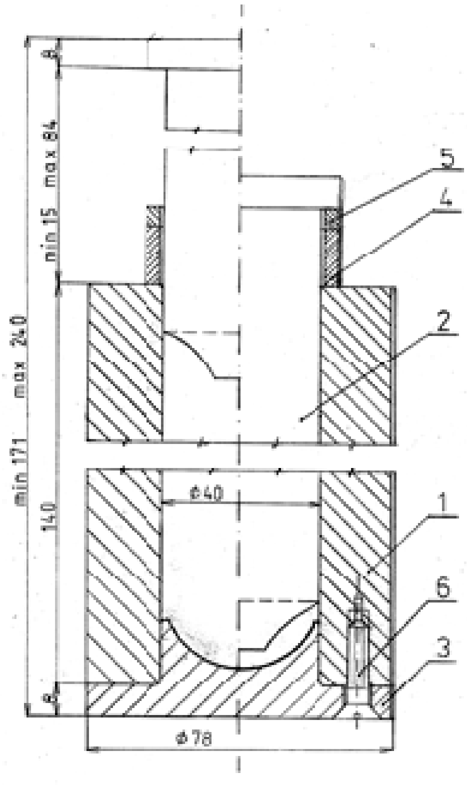

Figure 1. Briquetting form
1 - matrix, 2 - upper punch, 3 - lower punch, 4 - the spacer ring, 5 – 5 mm spacer ring, 6 - screws

Compression experiments were performed at the briquetting plant on the hydraulic testing machine HECKERT EU40 with a recording device (Figure 1).

Compacted briquettes get shape as shown at Figure 2. The dimensions of the briquettes are shown at the Figure 3.

The determined volume of sawdust V_1 with given weight m was poured into the form and was pushed into the cavity by the movement of the press ram of the upper punch 2. The motion ended when the punch reached the spacer ring 5, which was visually controlled. Altogether, 7 briquette samples have been produced with the volume of 40 to 100 cm^3 and weight from 10.9 to 21.9 g. Of these, only the last three were evaluated, marked as 1DB, 2DB and 3DB. After compressing, the volume of the briquettes Vs was found, and density was calculated according to the formula (1):

$$\rho = \frac{m}{V_s} \tag{1}$$

and the maximum compressive force F was recorded. These values are shown in Table 1.

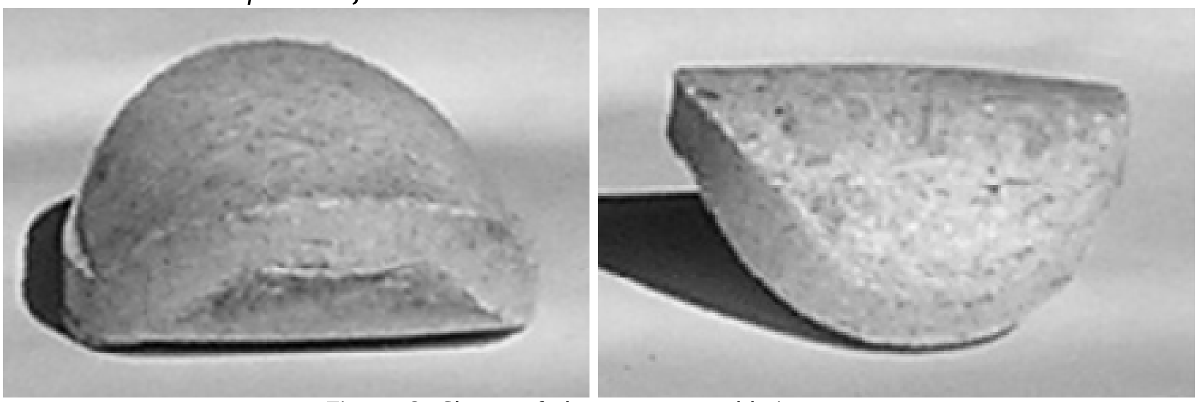

Figure 2. Shape of the compressed briquettes

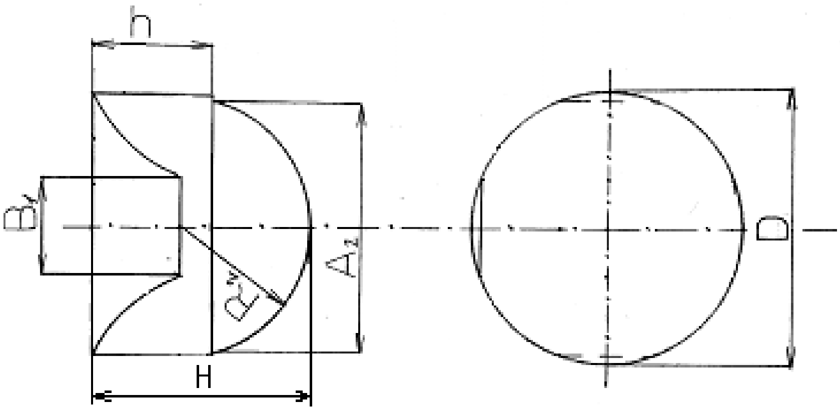

Figure 3. Dimensions of the briquettes

Table 1. Size of pressed briquettes

Sample	Briquettes dimensions B [mm]	C [mm]	D [mm]	H [mm]	h [mm]	R [mm]	Volume V_1 [cm^3]	Volume V_S [cm^3]	Density ρ [$kg.m^{-3}$]	Force F [kN]
1DB	15	37,7	41	23,4	11,4	20	100	15	1460	367
2DB	15	37,8	41,2	23,2	11,2	20	90	15	1393	274
3DB	15	38	41,4	23	11	20	80	15	1326	190

EXPERIMENTS EVALUATION

While pressing the briquettes, the pressing force F dependence on the track of the press ram l was recorded, i.e. punch l, shown on Fig. 4. Area A [mm^2] lying below the curve gives the work W required for compression.

This work can be determined by finding the area A, which is found in the evaluation of graphic records on graph paper by subtracting the surface A. Also the scale was determined, the amount of work representing 1 mm^2 = 0.4019 J. The practical importance is in determining the specific work W_m, i.e. work required to produce the specific mass weight of briquettes, according to:

$$W_m = \frac{W_i}{m_i} \qquad [kJ.kg^{-1}] \tag{2}$$

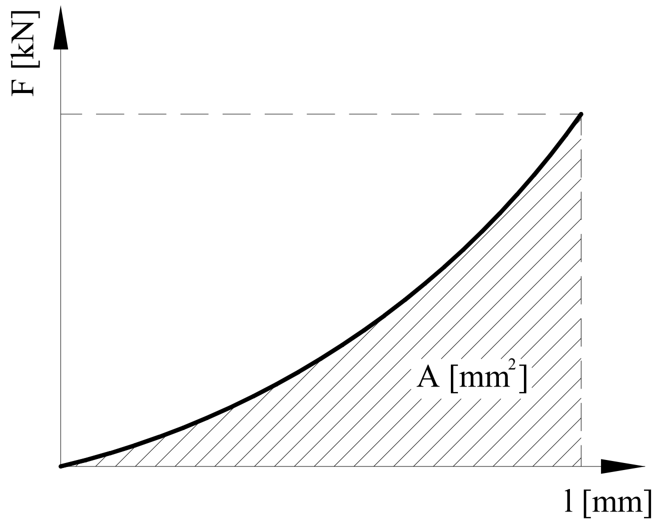

Figure 4. The course of the pressing force F on the track l

In determining the pressure p_0 it was considered the sawdust behave as a liquid, then the pressure incurred in the process of briquetting is the ratio of the force F and the area of the perpendicular diameter of the punch S_0:

$$p_0 = \frac{F}{S_0} \qquad [Pa] \tag{3}$$

In this case, both internal and external friction is negligible. It is difficult to determine the internal friction of wood chips, but the external is characterized by a friction coefficient between sawdust and cavity, f = 0.1. It induces the friction force T between the sawdust and the matrix cavity due to the intensity of the normal force N:

$$T = f.N \tag{4}$$

The normal force N is proportional to the contact area of briquettes and the matrix wall, S_i and the sawdust pressure during the briquetting process:

$$N = p_r.S_i \tag{5}$$

The real force F recorded during pressing is used up to overcome the reaction R acting on the punch and induced by the pressure p_0 acting to a square cut S_k = 1256 mm² and the friction force T and is expressed by the formula:

$$F = R + T \tag{6}$$

The reduced pressure p_r is then:

$$p_r = \frac{R}{S_0} = \frac{F-T}{S_0} = \frac{F - P_r.S_i.f}{S_0}$$

after adjustment:

$$p_r = \frac{F}{S_0 + S_i.f} \tag{7}$$

Sawdust and compressed samples 1DB, 2DB and 3DB were sent to laboratory analysis where the combustion heat Qs and calorific value Qv were determined. The parameters are listed in Table 2.

Table 2. Briquettes Parameters

Sample	Weight m [g]	Force F [kN]	Area A [mm²]	Work W [kJ]	Work W [kJ.kg⁻¹]	Pressure p_0 [MPa]	Pressure p_r [MPa]	Combustion heat Q_S [MJ.kg⁻¹]	Calorific value Q_{VS} [MJ.kg⁻¹]
1DB	21,9	367	3925	1,577	72	292	252	21,3	18,69
2DB	20,9	274	2548	1,024	48,99	218	188	19,95	17,43
3DB	19,9	190	2113	0,8	42,66	151	131	19,37	16,89

CONCLUSIONS

Experiments of sawdust briquetting shaped according to Drzymala demonstrated the applicability of this method. When compared with the cylindrical briquettes, which combustion heat, assessed by the same laboratory, is Q_s = 15.56 MJ.kg⁻¹ the concave ones show higher combustion heat

(Q_s) values. Since the input data for cylindrical briquettes production are not accessible, it is not possible to compare relevantly these two types of briquettes.

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