Possibilities of Utilization of Energy Briquettes

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***Abstract.* The analysis of mineral coal briquettes from charcoal and biomass together with molasses as a binding agent for utilization in industrial energy were presented. The physical-chemical properties of the material investigated, consisting of raw waste material, are described. The process for preparing the material into briquettes comprised of crumbled and mixed constituents, together with the specific reduction of moisture of the mixture, are presented. The effect of the selected parameters of the consolidation process in the pressing stamp on the toughness of briquettes is investigated. Analysis was made of such parameters as: contribution of the biomass in the mixture of charcoal and binder, moisture in the mixture, press pressure on the formation, and seasoning. The results confirm the possibility of utilizing high quality energy briquettes. They possess the high material strength as well as high value combustible fuel, which qualifies them for utilization in industrial energy.**

1. Introduction

Coal-biomass briquettes are an ecological source of energy and even frequently utilized in the production process for heating energy as well as in electric heating, such as in individual households. Briquettes produced at present contain pit coal, brown coal (lignite), coke together with biomass in the form of sawdust, peat, straw or other raw materials. Briquettes thus produced are without any additions or additional binding agents. Frequently used binders are starch, sugar, soda lye, water glass, lime, gypsum, and many others. The addition of these fine-grained binding agents to the composition of the briquettes increases their toughness [1, 2, 3].

For making the briquette charcoal-biomass mixture, stamping presses as well as rollers may be used. Rolled briquettes are definitely more efficient than those that are punched, and ought to have a wider application for production continuity. Stamping presses, however, check the determined properties of briquettes in laboratory conditions and also for the production of the specimens in small series. The mixture for merging on the press has to be appropriately prepared. Each individual ingredient has to be added in determined proportions, binder added, then thoroughly mixed together and the paste dried to a certain moisture [3].

Coal-biomass briquettes intended for burning in furnaces are characterized by a high energy effect. Their material strength has to be adjusted to transport conditions and storage, through which the toughness ought to be kept throughout the seasonal periods. In the case of transportation in sealed containers, the briquettes should be marked for additionally high water resistance.

Briquettes with biomass used as energy fuel comply with the standard regulations for the protection of the environment, especially in area of low emissions of harmful substances into the atmosphere [7]. The mass production of briquettes requires, moreover, preparation of high quality criteria and repeatable quality of this product. Appropriate laboratory experiments were carried out to put this aim into effect. The present work recommends preparation in this way of the mixture and manufacture of coal-biomass briquettes on a laboratory scale.

2. Materials for Energy Briquettes

The materials investigated were pit coal and sawdust from deciduous trees (oak and beech). The binder added to the mixture was molasses, a by-product obtained during the refining of sugar. The selection of this binder from among many others was motivated by the results of the author’s investigations with fine-grained briquette materials which confirmed the effect of molasses on the material strength of briquettes [3]. Also significant is the fact that it did not create any increase in harmful emissions during the burning process of briquettes of molasses in comparison with test controls.

The value of burnt biomass of deciduous wood rose in median to 19,000 kJ/kg. In comparison, the value of burning pit coal rose in median to 28,000 kJ/kg (Table 1). During the burning time the biomass produced a small amount of ash which did not contain harmful substances and may be utilized as mineral fertilizer [6].

The basic chemical ingredients of pit coal and biomass employed for energy are the same. The individual elements in chemical conjunction appear, however, in different proportions. The resulting measurements presented in Table 1 confirm that the biomass contains about four times more oxygen, twice as few charcoal elements, and likewise sulphur and nitrogen. The consequence of these properties is a higher air content and higher reactivity of biomass [8].

From the ecological point of view, the advantageous characteristics of wood biomass are significantly lower, in comparison with coal, sulphur and ash value measurements. The contribution of ash formed in wood burning is on the level of 2% and is significantly lower than for burning coal. The value of the air part, however, is significantly higher in biomass than with coal. The content of the element coal in the biomass is on the level typical for organic combinations [5].

Biomass possess a lower pouring density and therefore a bigger ingredient surface is required in comparison to the coal storage area. The biomass density increases on average

TABLE 1
CHARACTERISTIC OF CHARCOAL AND BIOMASS

Parameter	Pit coal	Biomass of deciduous wood
Density poured (kg/m^3)	880	80
Combustible value (kJ/kg)	28,000	19,000
Moisture value in investigation (%)	7.1	12.0
Value of air part (%)	26.6	66.5
Ash value (%)	12.2	2.0
Sulphur value (%)	0.9	0.1
Oxygen (%)	7.0	30.2
Coal (%)	81.0	42.0
Nitrate (%)	1.1	0.5

80 kg/m^3 at the same time as coal increases to ca. 880 kg/m^3 (Table 1).

The characteristic biomass attributes in its fresh form is a high value of moisture which increases as high as 50%. It is advantageous to decrease its moisture to a value lower than 15%. A high moisture content in the biomass also has an influence on its cost and profit. A higher weight of biomass relative to the appreciable water content increases the cost of transportation. The utilization of waste wood is therefore profitable through application of drying and integration of raw materials before its transportation to energy works. A very important characteristic mixture of coal-biomass is the complete additiveness of organic substances of both fuel. In this mixture, the coal plays a stabilizing role in the burning process. In comparing energy, 2 tons of biomass are equal to 1 – 1.5 tons of pit coal [4].

The combustible value of coal briquettes with 20% massive participation of wood biomass rises to ca. 24,000 kJ/kg, which is sufficient in order to employ it as a source of warming energy in electric generating plants. Such briquettes, moreover, are an ecological fuel complying with regulations for protecting the environment, relative mainly to the limitation of SO_2 emissions into the atmosphere, thanks to which desulphurisation of fumes is not required [9].

3. TOUGHNESS OF BRIQUETTES

Fine grain coal belongs to the materials that showed weak susceptibility for integration in pressing into briquettes. It is therefore desirable that the activity has the aim of changing the properties of the material. In investigations to date, the integration of fine grain materials has played a significant role factor combining the prepared material [2, 3].

The preparation of material for making into briquettes includes the crumbling and mixing as well as drying to a moisture level below of 12%. An electric mill is used for the crumbling. The relatively significant difference in the physical properties of coal and fibrous materials suit to two types of mill – coal hammer and shears (cutting) for fine graining into biomass. Coal together with sawdust were crumbled to the moment granules of less than 2 mm are obtained for analytical tests. The prepared briquettes were investigated for the balance participation of the biomass decreased in relation to coal to 20% and 25%. In accomplishing, the briquettes checked also only the coal. The molasses content in the role of binder, defined previous investigations, decreased to ca. 8% [3].

The ingredients were mixed in an electric mixer and then taken for thermal drying to a precise level of moisture. Investigation of the moisture was accomplished with the aid of laboratory moisture tester from the KETT firm, type FD-620. The drying temperature was increased to 100°C. The prepared briquette mixture was placed in the laboratory press. The maximum pressure of each individual press was increased to 35 MPa, whereas the press displacement was 200 mm.

Preparation and accomplishment of special forming unit to briquetting of fine grain waste materials were assembled in the matrix and punch. The matrix enables obtain briquettes of cylindrical shape and a suitable height of briquettes obtained of approximately 2/3 diameter. It is possible to quickly change the matrix and stamp for the purpose of obtaining briquettes of different dimensions and form.

The toughness of the briquettes were defined through resistance to gravity drop, together with the strength of compression. Resistance of the briquettes to gravity drop was evaluated through the percentage of decrease in mass after dropping the briquettes at least three times from a height of 2.0 m on to a steel plate. After each drop, the test piece was put through a sieve with openings smaller than the minimum dimension of the briquette. Briquette resistance to gravity is illustrated in the equation below:

$$K = \frac{B_z}{B} \cdot 100\% \qquad (1)$$

where: B – briquette mass before dropping,
B_z – mass remaining in filled sieve.

The gravitational resistance to drop should be attain a value higher than 90%. The value of compression strength destroying the briquette was defined experimentally as follows, that the cylindrical disc was placed between the flat surface of the compress experimental piece until the moment of destruction of its structure. The investigation carried out used an endurance test machine ZWICK Z100. The value of compression strength destroying the briquette should be attain at least 1.5 MPa.

4. ANALYSIS OF RESULT OF RESEARCH

Fresh and seasoned briquettes were tested. Analysis of the following parameters was undertaken: biomass contribution, moisture of the coal-biomass mixture with binder, pressure of stamping press and seasoning. Data from the analysis is presented in Table 2, as well in Figures 1 and 2.

The data presented in Table 2 shows that the majority of examples of gravitational resistance to drop obtained a value higher than 90%. This resistance is insufficient through integration in the material of moisture greater than 10%. It was ascertained that the mixture should contain a 6 – 9% of moisture. High resistance of the briquettes obtained by a

TABLE 2
TOUGHNESS OF SELECTED COAL-BIOMASS BRIQUETTES

Test No.	Moisture (%)	Punch pressure (Mpa)	Biomass participation (%)	Maximum compression strength destroying briquettes (Mpa)		Resistance to gravity drop (%)	
				fresh	seasoned	fresh	seasoned
1	11.5	30.0	20.0	1.08	1.54	80.0	82.0
2	9.6	30.0	20.0	4.81	7.37	89.0	90.5
3	8.0	35.0	20.0	4.42	6.80	97.5	98.2
4	7.9	35.0	25.0	5.30	8.14	95.6	96.3
5	7.5	30.0	25.0	6.03	9.24	94.8	95.6
6	7.4	35.0	25.0	7.45	11.64	97.1	99.0
7	6.6	35.0	0.0	1.19	1.83	82.6	83.5
8	6.3	30.0	20.0	4.84	7.44	93.7	94.0

punch press with pressure of 30 as well as 35 MPa. through which the greatest pressure value applied the biggest degree of crush; therefore, in effect, the material strength was higher. This is significant if the contribution of biomass in the briquettes is increased. For example, a 25% contribution of biomass in the samples produced with a smaller resistance; on the other hand, however, through increasing the strength value of pressure, samples are produced with a high toughness.

It was observed that in gravitational resistance drop tests the greatest resistance was proved in tests falling on to the surface of the circular disc, and the lowest when dropped on to the edge or flat part. This confirms the justification for constructing such a matrix and punch, so that the briquettes had not strong edges and even walls. Round-shaped briquettes can be formed in a roll press.

The data presented shows that briquettes consisting only of coal have a decidedly lower resistance to compression than briquettes with additional biomass. The use of biomass therefore increases the material strength of briquettes. Analysis of the data shows that the maximum strength value of compression is somewhat higher for briquettes with a 20% biomass, and lower for those with 25% biomass through using the same pressure strength in the press. It is justified to use a higher press pressure in the example of compressing material containing a higher biomass content.

Figure 1 presents data showing the seasoned precept of briquettes. Seasoned briquettes are characterised by a higher resistance to pressure than fresh ones. The results of experiments show that in the period of three weeks their resistance to pressure increases; however, seasoning for a longer time is disadvantageous. There is a distinct decrease in resistance to pressure after 50 days of seasoning the briquettes.

Analysis of the running curve in Figure 2 shows three phases in the compression of the briquettes. In the first phase, a small rise in compression strength induces a big relationship between the moving parts of the endurance machine, between which there are the test piece. The cause of this is a porosity of the briquettes. In this phase the compression process is introduced; therefore, there is a reciprocal close relationship between the ingredients of the fine grain structure of the briquettes. The next phase of the process is characterized by a stepwise increase in strength up to the maximum value whereby the test piece are destroyed.

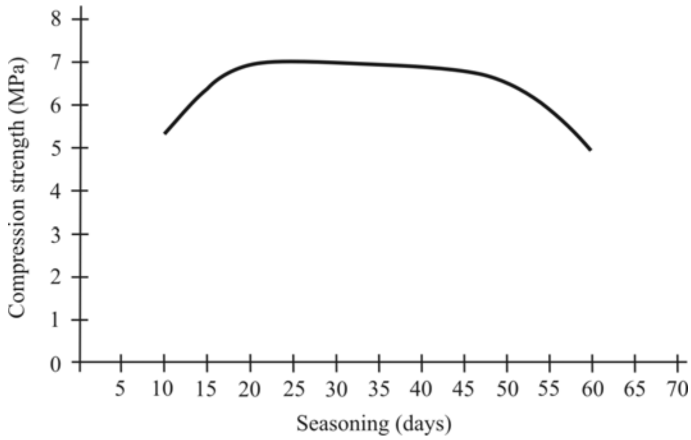

Figure 1. Reliability on compression of briquettes in relation to seasoning

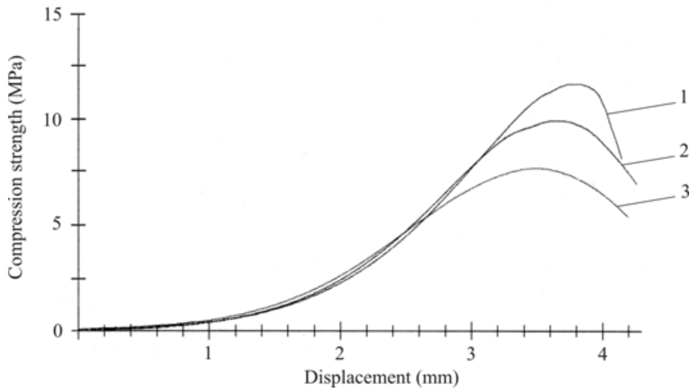

Figure 2. Course of compression strength of selected briquettes : 1 – made with punch pressure of 35 MPa, 2 – made with punch pressure of 30 MPa, 3 – like (2) with lower humidity of the mixture

5. CONCLUSION

The production of energy briquettes from coal and biomass produced a high toughness. An adhesive like molasses added in to the residual mixture produces increased material strength. Additional increase of mass participation of biomass does not produce a significant decrease in resistance of the briquettes, but lessen the energy effect during their burning in furnaces. The acquisition of a high value of resistance to gravitational drop, together with resistance to the compression, to a large degree depends on the moisture of the mixture, pressing stamp pressures, and likewise the period of briquette seasoning. It was proved that briquettes showed sufficient resistance, even in fresh form; however, it is advantageous to use them during a period of 2–4 weeks.

On the basis of the results of the investigation, the following are proposed:

1. During the process for preparing the mixture for making into briquettes, it is essential to select definite proportions of ingredients. The most advantageous conditions to assure the addition of the molasses in the amount of ca. 8% for the making of briquettes of grained materials, together with the drying of the mixture to a moisture level within the range of 6–9%. Seasoned briquettes influence their toughness.
2. The use of molasses as a binder significantly influences the increase in the material strength. They have sufficient resistance, even through the increase in biomass participation, but in this care it depends on the minimal burning output value of the briquettes in relation to the required energy effect acquired during burning in furnaces.
3. The energy effect during burning of briquettes in industrial furnaces should be obtained.
4. Briquetting of energy raw materials brings advantages for decreasing the consumption of materials, together with a lowering cost of transports and storage.

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