Study of strength characteristics of fuel briquettes from organic waste

Cite as: AIP Conference Proceedings **2212**, 020044 (2020); https://doi.org/10.1063/5.0000951
Published Online: 17 March 2020

A. S. Nikiforov, E. V. Prikhodko, A. K. Kinzhibekova, and Sh. M. Nurkina

Study of Strength Characteristics of Fuel Briquettes from Organic Waste

A.S. Nikiforov[1, a)], E.V. Prikhodko[1], A.K. Kinzhibekova[1] and Sh.M. Nurkina[1]

[1]*Pavlodar State University, 140000 Pavlodar, Kazakhstan.*

[a)]Corresponding author: sholpan_shupeeva@mail.ru

Abstract. GOST is used to determine mechanical strength of pellets and briquettes. Studies were carried out on the dependence of strength of briquettes on fractional composition. The strength result shows that at briquetting pressure 20 MPa, there is an increase in density with an increase in fraction at least 89%. The high mechanical strength of the briquette indicates that the briquettes will burn stably during burning process in boilers.

INTRODUCTION

Analysis of the current state of production of fuel briquettes from renewable organic materials, in particular, from fallen leaves, shows that unresolved questions about the influence of certain factors of the briquetting process on their characteristics (strength, density, combustion heat, ignition temperature, etc.) still remain.

The main factors that affect the strength properties of the briquettes are pressure, humidity and particle size, temperature modes and pressing time.

It is known that the strength, i.e. the ability of a material to resist external forces, is determined by the magnitude of its destructive force.

When hard particles are pressed, their destruction occurs, thus ensuring packing density and maximum contact of particles is provided, what leads to result in high strength of briquettes. Obviously, the stronger the particles of the material, the worse they break down and the weaker they compress. And with a smaller contact area, there is a lack of particle bonds, which negatively affects the strength of the briquettes.

MATERIALS AND METHODS

Strength of briquettes is formed under influence of considerable number of factors. It is evident that as many of these factors as possible need to be realized in order to obtain strong briquettes.

However, such an approach would be technically difficult to implement and economically inappropriate, as the use of all factors could produce excessively strong and excessively expensive briquettes, the use of which would not be cost-effective in production. It is therefore advisable to select the minimum number of factors required in accordance with the following selection criteria.

The factor must be:

- Implemented in industrial conditions, i.e. correspond to the state of development of briquetting technology;
- Significant, i.e. give strength gain, steadily exceeding measurement error (1% for instruments measuring mechanical strength for crushing and dropping, and 0.1% for density);
- effective, i.e. ratio “effectiveness of a factor: costs of its realization” has to be significant, essential.

Based on these requirements, the following factors are maximally used to ensure the strength of the briquettes: pressure of pressing, fractional composition of the raw material, type and amount of binder and methods of strengthening depending on the properties of the raw material.

For example, particles up to 2 mm are well briquetted and the density of briquettes is high, with an increase of briquettes up to 5 mm, a decrease in density is observed - briquettes become insufficiently strong. Larger particles do not allow to obtain a qualitative and solid briquette [1].

Thermophysical Basis of Energy Technologies (TBET 2019)
AIP Conf. Proc. 2212, 020044-1–020044-4; https://doi.org/10.1063/5.0000951
Published by AIP Publishing. 978-0-7354-1963-6/$30.00

The strength of the briquette is also affected by the temperature regime. The higher the temperature of the material to be pressed, the lower force is required during its pressing [2].

The amount of pressing pressure determines the work required to form the briquette. At the same time the pressure appears to be an index of density and further strength of briquette [3].

There are currently no common standards for strength determination. For example, it is possible to use the method of dropping briquettes from a height of 1.5 meters to a steel surface and to judge the strength used for coal briquettes by further sifting through [4]. Values of average strength of briquettes obtained according to this procedure are given in Table 1.

TABLE 1. Strength of organic mass briquettes

Experiment №	Pressing pressure, MPa	Average strength of the obtained briquettes, %
1	6	83
2	10	87
3	15	94
4	25	100

Other techniques suggest determining the limit of compressive strength. This method does not quite correctly determine the strength properties of organic waste fuel briquettes, since fibrous materials are used for the production of briquettes, and the direction of fibers in the material will largely determine the strength characteristics. Since the arrangement of fibres in the material is random, the application of this technique, in our view, is incorrect.

The procedure for determining the abrasion of fuel briquettes largely determines the characteristics of the briquettes during transportation.

In the literature, it is possible to see a clear gradation by the influence of the fractional composition on the strength of the final product. The smaller the fraction of the briquetable mass, the larger the contact surface area of the particles and the greater the adhesion force in the briquette. Accordingly to this information, it is necessary to grind the raw material to a minimum size.

However, there is also the other side of using coarse particles during briquetting leaves. Leaves briquetting in a mold are arranged randomly, and when compressed, the deformed sheet can pass through the entire thickness of the briquette. Thus, with the action of external forces seeking to destroy the briquette, in certain cases it is easier to “break” the particle from itself similar (overcoming the forces of adhesion of the particles) than to break the part from the sheet (additionally pressed). The main ratio in this case will be between the adhesion forces of the particles in the briquette (depending on the pressing pressure) and the breaking forces of a part of the dried and pressed sheet.

In this regard it was decided to conduct research of briquettes’ durability dependence on fractional structure. At the same time the fractional structure was taken by fraction from 0.2 mm to undivided ones (non-crushed leaves).

For determination of mechanical durability of briquettes GOST for determination of mechanical durability pellet and briquettes is used [5]. For this purpose a steel drum of a cylindrical form capable to rotate with a certain speed was made.

Tested briquettes in number of 2 kg were placed in a drum and subjected to controlled blows by collision of briquettes with each other and with walls of the rotating camera. For determination of durability test was rotated with a speed of 21±0.1 revolutions per minute within 5 minutes. After extraction from a drum the mass of the whole briquettes was determined. Mechanical durability was calculated on a formula [5]

$$DU = \frac{m_a}{m_e} 100 \quad (1)$$

where DU - mechanical strength,%;

m_A - weight of sample of briquettes extracted from drum, g;

m_E - mass of a sample of briquettes placed in a drum, g.

RESULTS AND DISCUSSION

The results of the study of the briquettes’ strength dependence on the fractional composition are given in Table 2.

TABLE 2. The briquettes' strength dependence on the fractional composition

Fraction	Strength according GOST R 55111-2012, %
from 0,2 to 1 mm	89
from 1 to 4 mm	93
from 4 to 15 mm	95
undamaged (non-crushed) leaves	96

The strength result shows that at briquetting pressure 20 MPa, there is an increase in density as the fraction increases. Briquettes of 0.2 to 1 mm fraction after strength measurement had smoothed ribs, and in addition, a portion of the briquette material transferred to the residue from both bases of the cylindrical briquette (Fig. 1). In the study of briquettes from unmodified leaves after strength measurement, it was also observed that the faces of the cylinder were rounded (to the same extent as the fraction of 0.2 to 1 mm), but the bases did not lose the briquette particles (Fig. 2).

(a) (b)

FIGURE 1. Samples of briquettes from 0.2 to 1 mm fraction: (a) - before strength measurement, (b) - after strength measurement.

(a) (b)

FIGURE 2. Samples of briquettes from non-crushed leaves: (a) – before strength measurement, (b) – after strength measurement.

The experiments carried out show that the increase in strength with the increase in fraction is practically non-existent during using a fraction of 4 to 15 mm and higher. This is because the dry leaves intended for briquetting when placed in the mold break due to their fragility. And if you analyze the ready briquette from unmodified leaves, you can say that its main fractional component is from 15 mm and higher.

CONCLUSIONS

Analysis of the results of the studies showed that the standard determination of the strength of fuel coal briquettes was not suitable for the study of organic waste briquettes. In the course of studies carried out to determine the strength of fuel briquettes from organic waste, we have found that the strength of briquettes obtained by pressing at a pressure of 20 MPa is not lower than 89%. This relatively low pressing pressure allows transportation of fuel briquettes from organic waste with minimal losses.

REFERENCES

1. M. V. Gomonay, *Production of fuel briquettes. Wood raw materials, equipment, technologies, operation modes* (GOU VPO MGUL Press, Moscow, 2006), p. 68.
2. S. I. Zavinsky, I. A. Telnov, A. G. Troshin, and V. F. Moiseyev, Influence of pressing pressure and temperature on properties of wood chips briquettes The Bulletins of NTU "KhPI" **10**, 144-149 (2012).
3. M. U. Balshin, *Scientific bases of powder metallurgy and fibre metallurgy* (Metallurgy, Moscow, 1972) p. 336.
4. GOST 21289-75 *Coal briquettes. Methods of determination of mechanical strength* (Standardinform, Moscow, 2010) p. 6.
5. GOST R 55111-2012 EN 15210-2:2010 *Solid biofuels. Determination of mechanical strength of pellets and briquettes* (Standardinform, Moscow, 2014) p. 6.