BRIQUETTE PROPERTIES AFTER THREE YEARS STORAGE

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Abstract. The paper presents the results of laboratory tests on the study of the influence of the storage place, placing manner and storage time on mechanical properties of briquettes made from birch chips. For production of the briquettes the briquetting press of the firm Briklis was used, type BrikStar 30-12, 50 mm pressure chamber diameter. All briquettes were made at constant adjustment of all parameters of the briquetting press. The briquette properties were evaluated by their density and rupture force determination. Moreover, the mechanical durability, gross calorific value, total moisture and the ash content were determined. By the carried out tests it was univocally proved that the mode of storage influences the briquette durability at their long-term storage. Most of all briquettes, deposited in a well closed plastic bag in a closed heated room, changed their properties during three years only minimally. Briquettes, deposited in the same place but in a plastic net bag, changed their properties much more. Briquettes, deposited in a closed unheated room, changed their properties during three years very considerably. Briquettes, deposited in a plastic net bag, changed their properties to such a degree that they were practically unusable. On the basis of the carried out tests it is possible to state that the rupture force can be recommended as the parameter of briquette quality evaluation.

Keywords: birch chips; gross calorific value; density; rupture force; moisture content; mechanical durability.

Introduction

Briquetting is a relatively old technology. The first mentions of their use have been published in the first half of the 18th century. The Otto's Encyclopedic Dictionary [1] describes relatively lengthily the basis and the use of briquetting and of briquettes in practice. The mention of briquetting technology and of briquettes can be found practically in all older as well as in new domestic [2; 3] and in foreign [4] encyclopedias.

In the last twenty years in the Czech Republic the briquetting technology asserted oneself in the field of metallic and non-metallic processing, too. The basis of this method is the high pressure effect on a fine-grained material. Briquettes, most often of cylindrical form and various diameter and length, are the final product. But briquettes can be of various shape, e.g., of cuboid with rounded corners, of hexagonal cuboid etc., according to the design of the press chamber of the used briquetting press.

The use of briquetting (or pelleting) technology can bring substantial savings. Waste pressed from flammable materials, e.g., from wood waste (chips, sawdust), straw, coal, paper, board, cellulose, tobacco etc. is mostly utilized energetically (by combustion) [5-13]. After its compression the waste from combustible materials, e.g., dust collected on air filters, abrasion dust or chips from cutting of metals and their alloys [14] is better usable. After compression the waste volume strongly decreases. This makes easy its handling and decreases the costs in transport or storage [15; 16] on a waste disposal site.

Materials and methods

On briquettes from wood waste for combustion a row of demands are laid, which are specified in relevant national directives. In the Czech Republic the demands on briquette properties are prescribed by the Directive of the Ministry of Environment No. 14-2009 [17]. It demands the briquettes minimum density of 900 kg·m^{-3}. The briquettes strength demands are not prescribed. Nevertheless, for operational reasons the adequate compactness is very important in order that at a common handling neither crumbling nor disintegration occur. The briquette minimum gross calorific value must be 17 MJ·kg^{-1}, the total moisture content max. 10 % by weight and the ash content max 1.5 %. Moreover, the briquettes must guarantee 9 months of the minimum storability. During this time the changes of the briquette size, density and moisture content must not exceed the limit of 10 %.

The tested briquettes were made from birch chips. For the briquette production the briquetting press of the firm Briklis (Malšice, Czech Republic), type BrikStar 30-12, pressure chamber diameter of 50 mm, was used. All briquettes were made at the briquetting parameter constant adjustment.

The aim of the carried out experiments has been to assess the properties of the newly made briquettes and of briquettes stored during three years under suitable and less suitable conditions. Briquettes were divided into four groups and deposited in the following storage spaces:

- Storage space I – in a closed heated room, in a plastic net bag and in a plastic bag;
- Storage space II – in a closed unheated room, in a plastic net bag and in a plastic bag.

The property changes of briquettes for the energy purpose have been studied [15; 16]. It was proved that during the briquette storage their properties changed already after several months. At the briquette storage in a closed heated room the changes are smaller than at their storage in a closed, but unheated room. But the radical influence occurs at storage in a closed plastic bag and in a plastic net bag.

After sampling the briquettes were numbered, weighted and their length and diameter measured. Then single briquettes were loaded by pressure using the universal tensile strength testing machine (Fig. 1). The test is finished at the briquette rupture, which is accompanied with rapid load decrease. From the load indicator the maximum load is taken down.

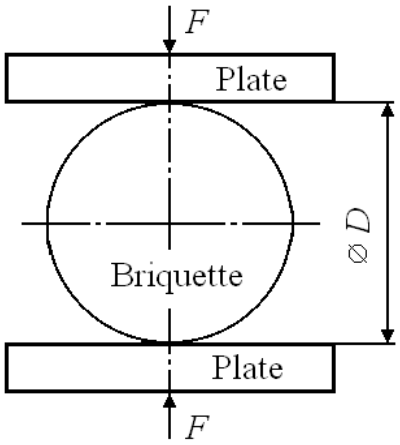

Fig. 1. **Principle of the plate-loading test**

From the measured values the briquette density was calculated. With regard to the production technology the briquettes are of different length. Therefore, their rupture force was recalculated and it is presented as the force per unit.

The determination of the mechanical durability according to CSN EN 14961-1 [18] and CSN EN 15210-2 [19] was the part of the carried out test. Moreover, the gross calorific value according to CSN EN 14918 [20], the ash content according to CSN EN 14775 [21] and the total moisture content according to CSN EN 14774-2 [22] were determined.

Results

The gross calorific value (20.1 $MJ \cdot kg^{-1}$) of birch chips used for briquette production was determined. The ash content (0.56 %) was determined.

The test results are presented in Fig. 2, Fig. 3 and Tab. 1. Fig. 2 presents the relationship between the rupture force and the density (for new briquettes). Fig. 3 presents the relationship between the rupture force and the density (for all tested briquettes; the average values from all measurements are plotted). In Fig. 2 and Fig. 3 the standard deviation is demonstrated by the line segments. All measured values were evaluated statistically (see Tab. 1).

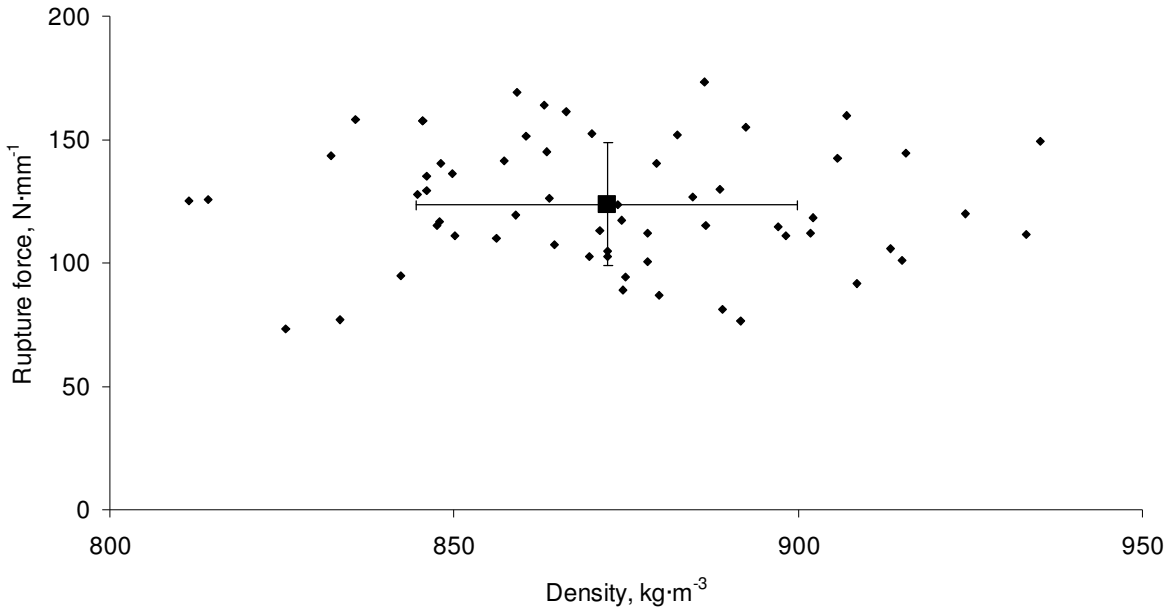

Fig. 2. **Relation between rupture force and density for new briquettes:** sample A in Fig. 3; standard deviation is demonstrated by the line segments

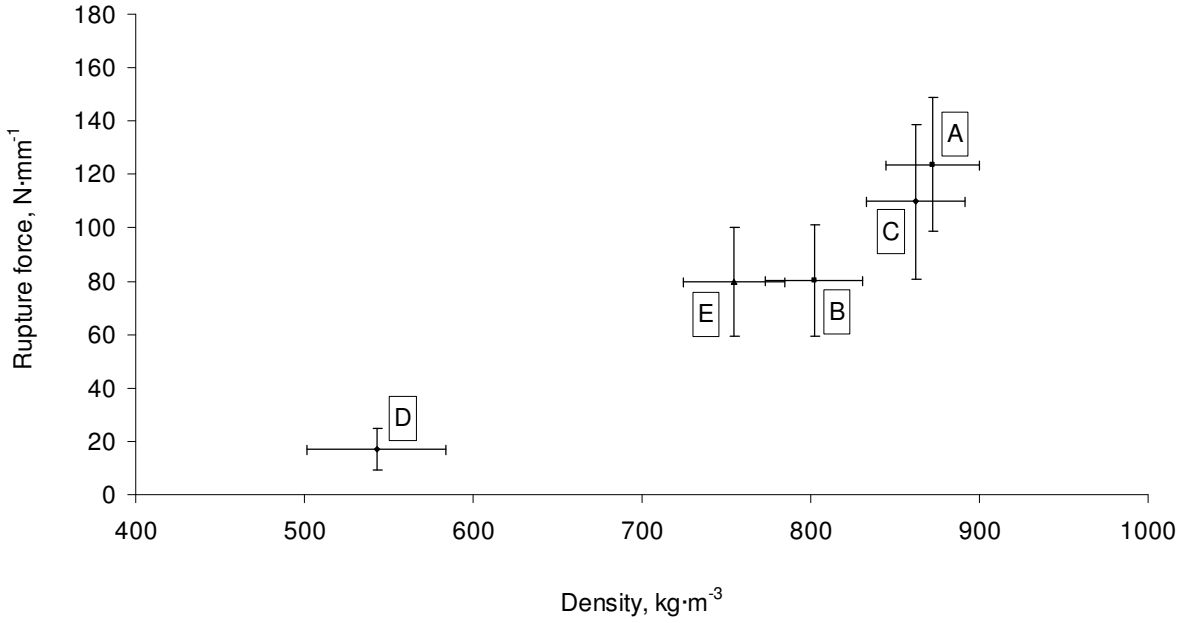

Fig. 3. **Relation between rupture force and density for all tested briquettes**: standard deviation is demonstrated by the line segments; sample A – without exposure; sample B – storage space I, plastic net bag; sample C – storage space I, plastic bag; sample D – storage space II, plastic net bag; sample E – storage space II, plastic bag

Table 1

Test results

Sample	A: Without exposure	B: Storage space I, plastic net bag	C: Storage space I, plastic bag	D: Storage space II, plastic net bag	E: Storage space II, plastic bag
Density, kg·m^{-3}	872.2 ± 27.7	802.1 ± 28.8	862.4 ± 29.3	542.8 ± 40.9	754.4 ± 30.0
Rupture force per unit, N·mm^{-1}	123.8 ± 24.9	80.3 ± 20.8	109.9 ± 28.9	16.9 ± 7.7	79.8 ± 20.6
Mechanical durability, %	92.6 ± 0.5	88.2 ± 1.6	89.9 ± 1.6	23.2 ± 3.1	81.2 ± 2.0
Moisture content, %	7.8	8.6	7.8	12.2	9.2
Weight, g	97.2 ± 12.2	95.1 ± 13.0	97.1 ± 13.3	96.2 ± 14.9	97.1 ± 15.0
Diameter, mm	52.13 ± 0.45	52.98 ± 0.52	52.34 ± 0.50	56.82 ± 1.09	53.68 ± 0.72
Length, mm	52.79 ±.6.29	53.82 ± 7.14	53.36 ± 7.04	70.32 ± 11.69	56.81 ± 8.27
Weight, g	97.2 ± 12.2	95.1 ± 13.0	97.1 ± 13.3	96.2 ± 14.9	97.1 ± 15.0

Discussion

From Fig. 3 and Tab. 1 it is evident that the density of the tested briquettes was only of 862.4 kg·m^{-3}, which is under the lower limit demanded by the Directive of the Ministry of Environment of the Czech Republic No. 14-2009. Considering the fact that briquettes of the same density are commonly marketed, the tests were carried out.

From Fig. 3 and Tab. 1 it is evident that the briquette density decreased after three year storage regardless of the storage space and manner. The insignificant density decrease (of 1.1 %) was determined at the briquettes stored in a plastic bag in a closed heated room (space I). Higher density decrease (of 8.0 %) was determined at the briquettes in a net plastic bag in a closed heated room (space I). On the contrary, at briquette storage in the plastic bag (of 13.5 %) or in the plastic net bag (of 37.8 %) in a closed unheated room (space II) a significant density decrease occurred.

Such results were determined at the rupture force. Although the Directive of the Ministry of Environment of the Czech Republic No 14-2009 does not prescribe watching of this parameter, the results are interesting. After the briquette storage in the plastic bag and at the plate-loading testing (Fig. 1) only the rupture force mild decrease (of 11.2 %) occurred, so that in this way stored briquettes meet the requirements also after three years storage. After storage in the plastic bag in the closed unheated room the rupture force decrease (of 35.5 %) occurred. After storage in the net bag the rupture force decrease occurred, namely at their storage in the closed heated room (of 35.1 %) as well in the closed unheated room (of 86.3 %).

At the briquettes stored in the closed heated room (place I) a relatively mild decrease in mechanical durability occurs (Tab. 1), namely at the briquettes stored in the plastic bag of 2.9 %, in the plastic net bag of 4.8 %. At the briquettes stored in the closed unheated room (place II) a significant decrease in mechanical durability occurs, namely at the briquettes stored in the plastic bag of 12.3 %, in the plastic net bag even of 74.9 %.

After long-term storage the briquette moisture changed, but relatively little. At three from four samples it was after three years lower than 10 %. Only at storage in the plastic net bag in the closed unheated room it increased considerably, namely up to 12.2 %.

From evaluation of the mentioned tests it follows that in the course of long-term storage the briquette loosening occurs. Their size (diameter, length) becomes larger, their density as well as the rupture force decrease (Tab. 1). Contemporarily their mechanical durability decreases. The change of the moisture content depends first of all on the storage location and conditions. In conclusion it is possible to state that briquettes degrade and at that practically all watched parameters get worse.

From the test results it follows that the storage time is of no substantial influence on the briquettes durability, but primarily their storage space and manner. According to the producers' recommendation

dry and heated rooms can be considered as suitable spaces. On the contrary, unheated spaces are less suitable. Briquettes should be always stored in leakproof closed plastic containers.

Conclusions

In the paper the study results of three factors influencing the briquette mechanical properties at long-time storage are presented. Density and rupture force were criterions for briquette evaluation. Other parameters were also watched, namely the mechanical durability, moisture content, diameter, length and weight of briquettes.

By the carried out tests it was unambiguously proved that the manner of briquette long-term storage is of the highest influence on their durability.

Briquettes, stored in a well closed plastic bag in a closed heated room, changed their properties after three years only little. The density decreases of 1.1 %, the mechanical durability of 2.9 % and the rupture force of 11.2 %. Briquettes, stored in the same place, but in a plastic net bag, changed their properties substantially more. It was clearly evident from the value of the rupture force which decreased of 35.1 %. The density decreased of 8.0 %, the mechanical durability of 4.8 %.

Briquettes, stored in the closed, but unheated room, changed their properties after three years very considerably. At their storage in the plastic net bag the decrease in density of 13.5 %, mechanical durability of 74.9 % and rupture force of 86.3 % occurred. These briquettes were practically unusable.

On the basis of the carried out tests it follows that for the briquette quality evaluation it is possible to recommend the parameter rupture force.

From the above mentioned conclusions it follows that briquettes should be always stored in leak proof well closed plastic containers. If briquettes are by their producers supplied in different containers or even in bulk it is without delay necessary to transfer them into suitable containers. Only in this way it is possible to guarantee their demanded properties also after three year storage.

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