Briquettes Properties after Four Years Storage

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

Keywords: briquettes; briquetting press; poplar chips; storage place; long-term storage

1 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 [18] 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 in newly domestic [13, 23] as well as in foreign encyclopedias [24].

In the twenty last years in the Czech Republic the briquetting technology [16] asserted oneself in the field of metallic [6] and non-metallic processing [1, 4, 5, 8, 9, 10, 21], 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 (and pelleting) technology can bring substantial savings. Materials pressed from flammable materials, e.g. from wood waste (chips, sawdust), straw, coal, paper and board, cellulose, tobacco etc. is mostly utilized energetically (by combustion) [2, 3, 7, 11, 14, 15, 17, 19, 20, 22]. 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 [31, 32] is better usable. After compression the waste volume strongly decreases. This makes easy its handling and decreases costs in transport or storage on a waste disposal site.

The aim of carried out experiments has been to assess the properties of the newly made briquettes and of briquettes stored during four years under suitable and less suitable conditions.

2 Materials and methods

On briquettes from wood waste determined for combustion a row of demands are laid, which are specified in relevant national directives. In the Czech Republic the demands on briquettes properties are prescribed by the [12]. It demands the briquettes minimum density of 900 $kg \cdot m^{-3}$. 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 briquettes minimum gross calorific value must be 17 $MJ \cdot kg^{-1}$, 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 briquettes size, density and moisture content must not exceed the limit of 10 %.

The tested briquettes were made from poplar chips. For the briquettes production the briquetting press of the firm Briklis (Malšice, Czech Republic), type BrikStar 30-12, pressure chamber diameter of 50 mm, was used [25]. All briquettes were made at the briquetting parameters constant adjustment.

Briquettes were divided into four groups and deposited in following storage spaces:

Storage space I – in closed heated room, in plastic net bag and in plastic bag,

Storage space II – in closed unheated room, in plastic net bag and in plastic bag.

Plastic net bags (so called raschel bags) are universal packaging material. They are lightweight, strong and breathable. They are used e.g. for storage of vegetables (potatoes, onions, carrots), fruit (apples, oranges), lump wood, wood chips etc.

Plastic bags have universal use. Bags were made from LDPE (low density polyethylene) with a thickness of 150

microns. They have high strength, stored material protects from moisture and dust.

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 the rapid load decrease. From the load indicator the maximum load is taken down.

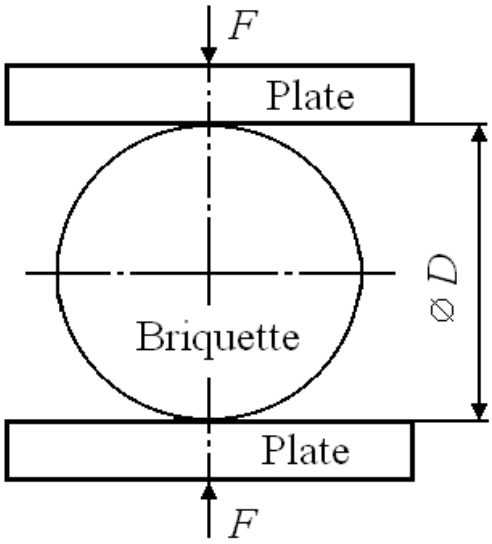

Fig. 1 *Principle of the plate-loading test*

From the measured values the briquettes 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 [29, 30] was the part of carried out test. This test simulates the effect of transportation to change the properties of briquettes.

Moreover the gross calorific value according to CSN EN 14918 (2010), the ash content according to [27] and the total moisture content according to [26] were determined.

3 Results and discussion

The gross calorific value (18.5 $MJ \cdot kg^{-1}$) of poplar chips, used for briquettes production, was determined according to [28]. The ash content (0.59 %) was determined according to [27].

The test results are presented in Fig. 2, Fig. 3 and Tab. 1. Fig. 2 presents the relationship between rupture force and density (for new briquettes). Fig. 3 presents the relationship between rupture force and 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).

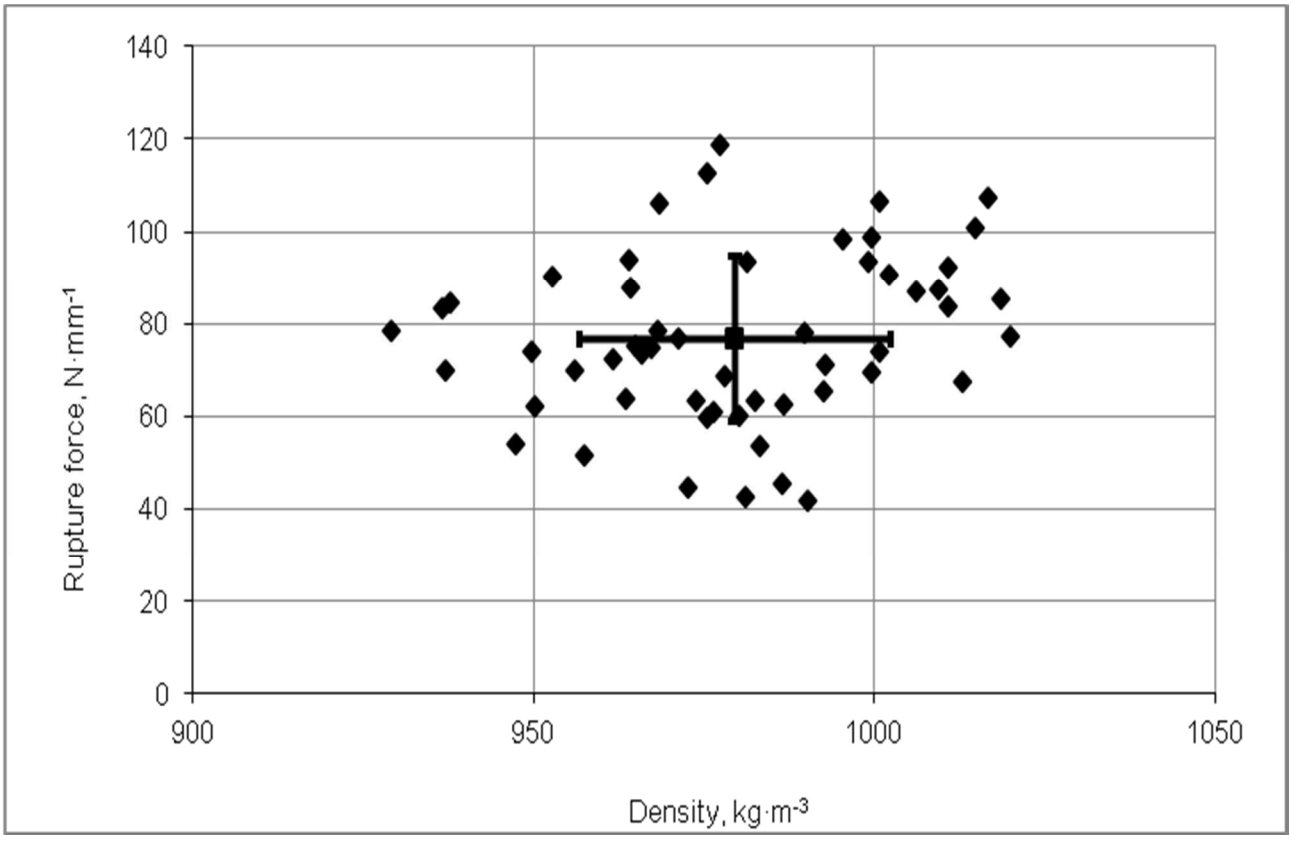

Fig. 2 *Relation between rupture force and density for new briquettes (sample A in Fig. 3; Standard deviation is demonstrated by the line segments)*

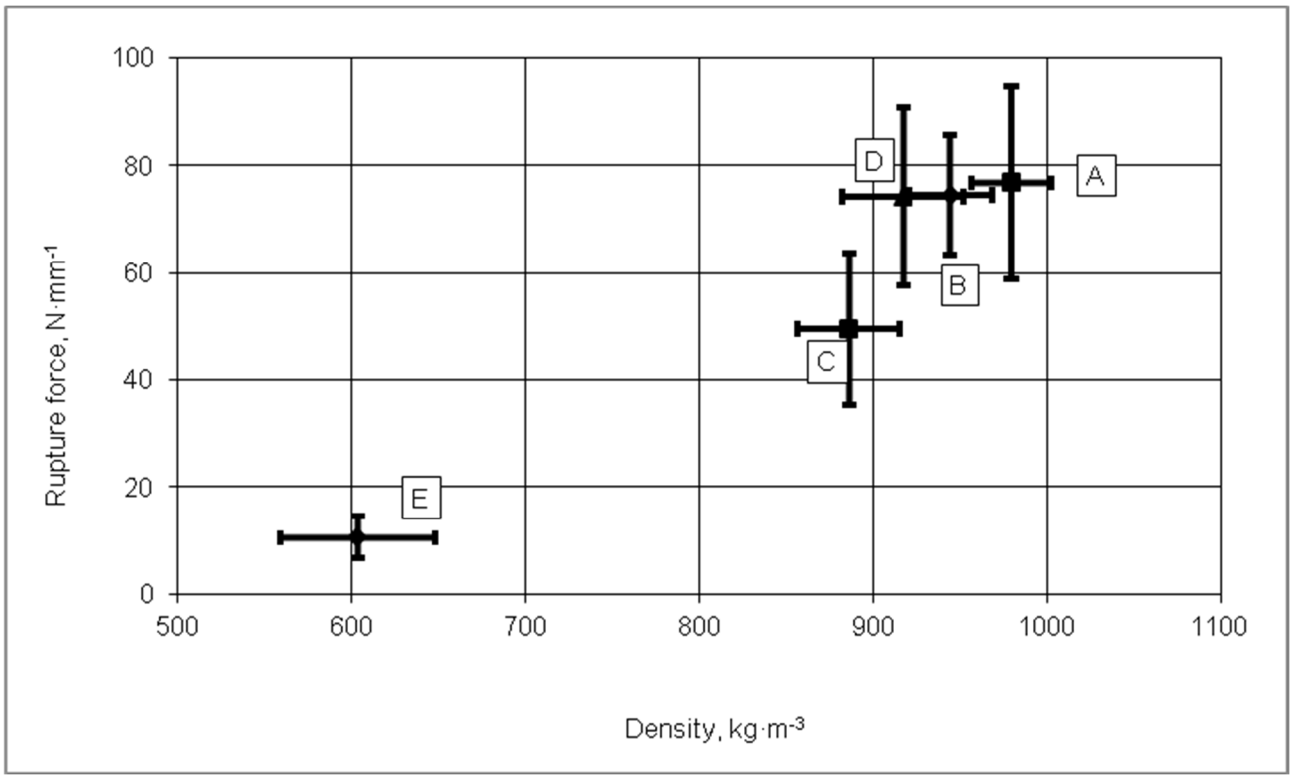

Fig. 3 *Relation between rupture force and density for all tested briquettes (standard deviation is demonstrated by the line segments): sample A – without exposure; sample B – storage space I, plastic bag; sample C – storage space I, plastic net bag; sample D – storage space II, plastic bag; sample E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

Tab. 1 *Test results*

Sample	A: Without exposure	B: Storage space I, plastic bag	C: Storage space I, plastic net bag	D: Storage space II, plastic bag	E: Storage space II, plastic net bag
Density, kg·m^{-3}	979.5 ± 22.8	944.6 ± 23.6	886.3 ± 29.2	917.5 ± 35.0	603.7 ± 44.9
Rupture force per unit, N·mm^{-1}	76.8 ± 17.9	74.5 ± 11.2	49.5 ± 14.3	74.2 ± 16.5	10.5 ± 3.9
Mechanical durability, %	95.6 ± 0.1	95.6 ± 0.3	91.0 ± 0.7	93.8 ± 0.2	38.9 ± 11.4
Moisture content, %	7.2 ± 0.0	7.4 ± 0.0	7.4 ± 0.0	7.5 ± 0.0	11.0 ± 0.1
Diameter, mm	51.27 ± 0.29	51.26 ± 0.39	51.72 ± 0.68	52.18 ± 0.32	56.01 ± 1.43
Length, mm	65.79 ± 6.23	54.93 ± 5.80	77.00 ± 2.79	56.85 ± 5.67	74.88 ± 5.79
Weight, g	133.0 ± 12.3	107.0 ± 10.5	143.3 ± 5.8	111.7 ± 13.5	111.0 ± 9.3

From Fig. 3 and Tab. 1 it is evident that the briquettes density decreased after four years storage that is regardless of the storage space and manner.

The practically insignificant density decrease (of 3.6 %) was determined at briquettes (sample B) stored in the plastic bag in the closed heated room (space I). Higher density decrease (of 9.5 %) was determined at briquettes (sample C) stored in the net plastic bag in the closed heated room (space I) and at briquettes (sample D) (of 6.3 %) stored in the plastic net bag in the unheated room (space II). On the contrary at briquettes (sample E) storage in the plastic net bag in the closed unheated room (space II) the significant density decrease occurred (of 38.4 %).

Such results were determined at the rupture force. Although the Directive of the Ministry of the Environment of the Czech Republic № 14-2009 does not prescribe the watching of this parameter, the results are interesting.

After the briquettes storage in the plastic bag in the closed heated room (sample B) and at the plate-loading testing (Fig. 1) only the rupture force mild decrease (of 1.7 %) occurred, so that in this way stored briquettes meet the requirements also after four years storage. After storage in the plastic bag in the closed unheated room (sample D) the rupture force decrease (of 3.4 %) occurred. After storage in the net bag the rupture force

decrease occurred, namely at their storage in the closed heated room (sample C, of 35.5 %) as well in the closed unheated room (sample E, of 86.3 %).

At the briquettes is different decrease in mechanical durability occur (Tab. 1). At the briquettes stored in space I in the plastic bag (sample B) of 0.0 %, in the plastic net bag (sample C) of 4.8 %. At the briquettes stored in space II in the plastic bag (sample D) of 1.9 %, in the plastic net bag (sample E) even of 59.3 %.

After the long-term storage the briquettes moisture changed, but relatively little. At three from four samples it was after four years lower than 5 %. Only at storage in the plastic net bag in the closed unheated room (sample E) it increased considerably, namely up to 11.0 %.

From the mentioned tests evaluation it follows that in the course of the long-term storage the briquettes loosening occurs. Their size (diameter, length) is changing. Their density as well as the rupture force decreases (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, at that practically all watched parameters get worse.

From the test results it follows that on the briquettes durability the storage time is of no substantial influence, but primarily they are their storage space and manner. According to the producer recommendation the dry and heated rooms can be considered as the suitable spaces. On the contrary unheated spaces are less suitable. Briquettes should be always stored in leak-proof closed plastic containers.

4 Conclusions

In the paper the study results of three factors influencing the briquettes mechanical properties at the long-time storage are presented. The influence of the briquettes storage space (closed heated room, closed unheated room) was the first studied factor, the second the storage manner (plastic bag, plastic net bag) and the third the storage time (new briquettes, briquettes after four years storage). Density and rupture force were criterions for the briquettes evaluation. Contemporarily next parameters were also watched, namely mechanical durability, moisture content, diameter, length and weight of briquettes.

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

Briquettes, stored in the well closed plastic bag in the closed heated room (space I, sample B), changed their properties after four years only little. The density decreases of 3.6 %, the mechanical durability of 0.0 % and the rupture force of 1.7 %. Briquettes, stored in the same place, but in the plastic net bag (sample C), changed their properties substantially more. Clearly it was evident from the value of rupture force which decreased of 35.5 %. The density decreased of 9.5 %, the mechanical durability of 4.8 %.

Briquettes, stored in the closed, but unheated room (space II), changed their properties after four years significantly. At their storage in the plastic bag (sample D) the decrease in density of 6.3 %, mechanical durability of 1.9 % and rupture force of 3.4 % occurred. At their storage in the plastic net bag (sample E) the decrease in density of 38.4 %, mechanical durability of 59.3 % 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 briquettes 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 four years storage, too.

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