QUALITY ASSESSMENT FOR BRIQUETTES MADE OF BIOMASS FROM MAPLE [*ACER NEGUNDO L.*] AND BLACK LOCUST [*ROBINIA PSEUDOACACIA* L.]

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Abstract. The purpose of the work was to carry out studies covering assessment of possibilities to use biomass from maple and black locust sprouts in briquette production. The research included determination of basic qualitative parameters characterising granulate for energy production that is density, calorific value, durability and ash content. Obtained results presented in tables indicate that briquettes made of wood from the examined tree species meet qualitative requirements specified in applicable standards.

Key words: biomass, biofuels, energy plants, qualitative parameters

Introduction

In recent years production of solid biofuels based on biomass from agriculture becomes increasingly important. As a result of the need for the energy sector to meet legal requirements concerning energy production from renewable sources, there is growing demand for solid biofuels, in particular from the so-called agrobiomass. Legal changes connected with biomass classification and concern for forest resources have caused that the share of biofuels produced from agrobiomass burned by energy production plants over 5 MW is continuously growing, and is to reach 100% in 2015. Whereas, in case of large energy production plants (over 20 MW) this share should reach max. 60% in 2017 [Dz.U. 2008 nr 156 poz. 969 - O.J. (Poland) no. 156 of 2008, item 969].

Thus, we may expect further increase in production of biofuels from biomass received from the agricultural sector, e.g. from cultivation of energy plants. This biomass called agrobiomass will play an increasingly important role in the balance of raw materials for energy production. Therefore, in the case of the developing agricultural sector, agrobiomass production becomes a chance of stable production for a large industry branch [Szajner 2011].

However, while analysing current market situation as regards the so-called agro biomass and biofuels, we may observe that the demand is considerably higher than the supply. Resulting from this is constant, and in the last year rather considerable, increase in prices of biomass (in particular agrobiomass) and growing import of products, which may be classified as biomass from agriculture (e.g. sunflower hull, fruit stones, etc.). Therefore, agriculture faces a great challenge of satisfying the market demands of the energy production sector.

In order to enable effective use of the existing potential in agriculture (soil, infrastructure), it is necessary to introduce in production modern techniques, technologies and plant species allowing to get heaviest crops. Therefore, it is essential to carry out research and development works aimed to provide reliable information for biomass and biofuel producers [Grzybek 2011].

When analysing the structure of agricultural raw materials available in the market for biofuel production, we may observe that significant biomass growth is possible only in specialised production (energy plantations). Potential for increasing production volume for biomass as production residue, e.g. straw, is limited and in many places in Poland simply impossible due to negative balance of soil and feed needs.

Therefore, development in energy plant cultivation for biomass production purposes is inevitable. However, the following questions are still without answer: what, where and how to cultivate and how to process these plants to allow optimal production potential utilisation. The issues involved in cultivation of individual plants are entered into in many research centres, whereas many questions related to their conversion in biofuels remain unanswered. One of the issues involves assessing the potential for producing good quality biofuels from individual biomass types, so as to avoid situations when as a result of processing a particular biomass type it would be impossible to receive biofuel (briquette or pellet) with required qualitative parameters. A situation is possible in which, due to energy expenditures incurred in order to obtain fuel of full value, its production would become unprofitable (e.g. high agglomeration pressure is required).

In connection with the above, it is necessary to carry out studies in order to assess if it is possible to produce biofuel with parameters specified in applicable standards from individual biomass types. European standards (EN) have been introduced in recent years which specify qualitative parameters for solid biofuels, and which allow for carrying out the above-mentioned assessment.

Research purpose and methods

Therefore, the main purpose of this work is to carry out complex assessment of properties for solid biofuels - briquettes produced of biomass from maple [*Acer negundo L.*] and black locust [*Robinia pseudoacacia L.*] to verify its usability as raw material for fuel production. The scope of the studies carried out covered determination of qualitative parameters as per applicable standards:

- specific density [$kg \cdot m^{-3}$] PN-EN 15103:2010,
- calorific value [$MJ \cdot kg^{-1}$] PN-EN 14918:2010,
- humidity [%] PN-EN 14774-2:2010,
- ash content [%] PN-EN 14775:2010,
- mechanical strength of granulates [%] PN-EN 15210-1:2010 - pellet, PN-EN 15210-2:2010 - briquettes
- geometrical features [mm].

Tested briquettes were made in a production line belonging to the laboratories of The Department of Mechanical Engineering and Agrophysics (Fig. 1).

The JUNIOR briquetting machine is a hydraulic device with an open working chamber and nominal diameter – 50 mm. In the completed tests agglomeration pressure has been set at three levels: 47, 37 and 27 MPa, in order to show its impact on the examined properties. The briquetting machine is equipped with gravitational ante-chamber filling system.

Fig. 1. Hydraulic briquetting machine with an open chamber from POR, model: JUNIOR

Fig. 2. Beater mill for biomass grinding from POR, model: KING c120

Material under investigation (biomass from two tree species) was taken from Energy Plants Collection at the Department of Production Engineering and Energetics (Fig. 3). Maple and black locust belong to fast growing plants, which may be grown in energy plantations [Kraszkiewicz 2008, Frączek et al. 2009]. Raw material for briquette production was shredded in a drum chopper, and then in a beater mill equipped with sieves: ø10 mm and ø15 mm (Fig. 2). According to the instructions provided in the standards, humidity of materials was set at 14%.

Durability is a measure of the fuel's resistance to shock and/or abrasion occurring during transport and other technological (logistic) processes. An examined sample is put to a test, in which fuel particles collide with each other and with the tester chamber walls. Durability is calculated as the ratio of mass of the fuel sample remaining after the test and the initial sample mass.

In case of briquettes, a sample weighing approximately 2 kg is placed in a cylindrical chamber equipped with a special partition. Tester chamber speed is 21 rpm, and measurement time is 5 min.

Calorific value was determined using the calorimetric method in a KL12 stand from *Bit Precyzja*. Measurement method was in conformity with the guidelines specified in the applicable standard and in the test stand instructions (Fig. 4).

Ash content measurement was carried out with the gravimetric method, using a muffle furnace manufactured by Snol (Fig. 5), allowing sample incineration at the temp. of 550°C. Ash was weighed using a laboratory balance with measurement accuracy of 0.0001 g.

Source: author

Fig. 3. Black locust plantation

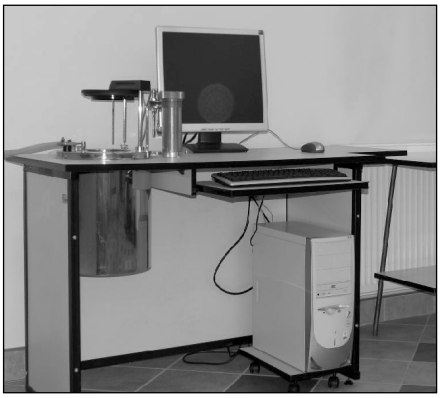

Fig. 4. Test stand used to examine thermal properties – KL12 calorimeter

Fig. 5. Muffle furnace from SNOL

Research results and discussion

At the final stage material prepared for briquette production was subject to grinding process. In order to characterise obtained material, the researchers carried out a test to determine size distribution. Obtained results are shown in Fig. 6. While analysing the results, one may observe that material received from the ϕ10 sieve is characterised by higher share of smaller particles in dust fraction size range – 1.6 mm.

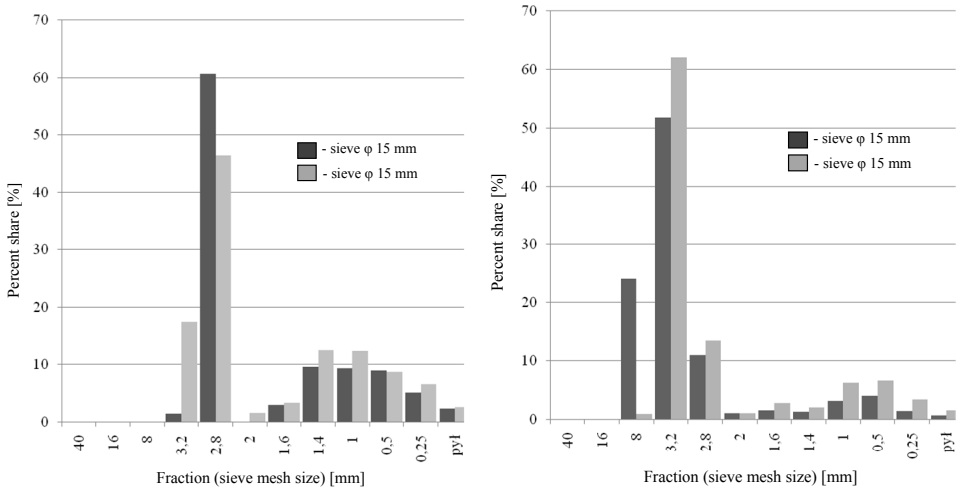

Fig. 6. Size distribution of raw materials prepared for briquetting process: a – maple [*Acer negundo L.*], b – Black locust [*Robinia pseudoacacia L.*]

Obtained research results concerning qualitative parameters of the examined briquettes are shown in table 1.

Table 1. Qualitative parameters of briquettes

Qualitative parameter	Maple						Black locust					
	Mill sieve mesh size [mm]											
	ϕ15			ϕ10			ϕ15			ϕ10		
	Agglomeration pressure [MPa]											
	27	37	47	27	37	47	27	37	47	27	37	47
Durability [%]	81.22	88.33	94.68	82.47	87.91	95.62	79.83	85.04	95.48	85.14	93.69	96.27
Specific density [kg·m^{-3}]	720.7	806.3	870.4	715.2	811.3	894.5	746.4	823.5	917.6	785.6	852.5	921.4
Dimensions D x L [mm]	51.4x43.8	51.5x41.1	51.7x39.9	51.3x47.4	52.3x46.5	51.2x44.8	51.8x39.4	51.5x38.6	51.2x38.2	51.9x45.6	51.1x44.4	51.2x44.9
Ash content [%]	0.93 ± 0.03						1.08± 0.04					
Calorific value [MJ·kg^{-1}]	17.23± 0.65						17.86± 0.73					

Source: own computations

While analysing obtained research results we may observe that the examined qualitative parameters of produced briquettes have high values as regards their use for energy production purposes. Durability of tested briquettes ranged from 79.83 to 96.27%. This may be considered a good result in the light of applicable standards, wherein the lowest acceptable value is 80%. Only in case of briquetting biomass from black locust, screened through a ϕ15 mm sieve, product durability dropped slightly below 80% for lowest examined pressure value (27 MPa). Highest durability values were acquired for briquettes made of raw materials shredded in a mill with a ϕ10 mm sieve and at highest pressure value: 47 MPa (96.27% - black locust, 95.62% - maple). This is due to the fact that fine particle fraction increases during grinding through a sieve with finer mesh (ϕ10 mm), and in agglomeration process these particles fill intermolecular spaces among larger particles very well. Increasing number of contact points in the mass at relatively high pressing pressure ensures higher number of intermolecular bonds, and thus a structure characterised by high strength and specific density is obtained, which has been confirmed in further studies. The tested specific density of briquettes proved that at agglomeration pressure of 27 MPa samples from both analysed fractions failed to meet the criterion specified in applicable standard: min. 800 $kg \cdot m^{-3}$. Therefore, we may assume that in order to satisfy applicable standards it is necessary to run agglomeration processes at the pressure of 37 MPa or higher. It is particularly important, because increase of agglomeration pressure results in growing energy consumption, and thus rising production costs. In case of examined calorific value, results obtained for maple (17.23 $MJ \cdot kg^{-1}$) and black locust (17.86 $MJ \cdot kg^{-1}$) are much the same. These values are close to the results obtained for other plant species, e.g. oak 17.62 $MJ \cdot kg^{-1}$ (chopped logs and round timber) and 17.90 $MJ \cdot kg^{-1}$ (branches) [Haufa, Wojciechowska 1986].

Summary

Completed research has proven unequivocally that there is potential for using biomass from maple and black locust in fuel briquette production. The values of examined qualitative parameters fit within ranges accepted in applicable standards. Tested briquettes have been made using conventional production technology, which means there is potential for wider use of this material type in solid biofuel production. In order to increase competitiveness of briquettes produced from the examined biomass it would be necessary to carry out optimisation studies allowing to reduce production costs while keeping qualitative parameters at proper level.

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OCENA JAKOŚCIOWA BRYKIETÓW WYTWORZONYCH Z BIOMASY KLONU JESIONOLISTNEGO ORAZ ROBINII AKACJOWEJ

Streszczenie. Celem pracy było przeprowadzenie badań mających na celu ocenę możliwości wykorzystania w produkcji brykietów biomasy z pędów Klonu jesionolistnego oraz Robinii akacjowej. Badania obejmowały oznaczenie podstawowych parametrów jakościowych opisujących granulat energetyczny tj. gęstość, wartość opałowa, trwałość oraz zawartość popiołu. Uzyskane wyniki przedstawione tabelarycznie wskazują, iż brykiety wytworzone z badanych gatunków roślin spełniają wymagania jakościowe zawarte w odpowiednich normach.

Słowa kluczowe: biomasa, biopaliwa, rośliny energetyczne, parametry jakościowe

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