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THE COMPARISON OF WOOD PELLETS PROPERTIES DEPENDING ON THEIR PRODUCTION PROCESS

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Abstract
Pellets from biomass are more and more used. As input material can be used various types of biomass, like wood, straw, grass or different organic materials. A lot of people want to produce pellets from biomass in domestic condition. But qualities of these pellets don´t achieve quality of pellets made in manufacture. Process of production wood pellets is difficult and this process has an impact on the final properties of pellets. The article deals with the comparison of the energy and mechanical properties of experimental pellets that have been made under different conditions. Sample A was produced in domestic conditions and sample B was made in factory production. At the end of the work are displayed the results of moisture, volatiles, fixed carbon content, ash content, elemental analysis, gross calorific value, calorific value and mechanical properties.

Key words: *wood pellets, production, properties, process*

INTRODUCTION

The development of renewable energy constitutes a crucial role for the future. Dendromass and phytomass play important role in reducing fossil fuel consumption. Wood pellets and plant pellets are a form of biomass (Ďurčanský et al. 2016). Pellets are usually produced from a variety of residue feedstocks, for example: straw, sawdust, wood (agricultural and forest biomass). They are easy to store and transport (Dzurenda and Pňakovič, 2016). They are cylinders with a diameter of 6-10 mm and a length of 10-50 mm manufactured from raw wood (chips, sawdust). They are made by compression process, called pelletizing. They don't usually contain chemical additives (Nosek and Holubčík, 2016). The important parameter for fuel properties is abrasion resistance. Pellets of low abrasion resistance have low quality, because high quantities of fines are produced in the storage system. It can cause operational failures. In turn, minimal amounts of fines in the storage system indicate on a high quality of pellets (Nosek et al. 2016). In addition, water has a crucial role in the pelletizing process. Pellets, which contain the low amount of water, generally have good quality and appropriate fuel properties (Rimár et al. 2016).

Pellets from biomass are usually made in factories with pelletizing line which can produce more than 2 tons pellets per hour. These manufactories have usually perfect working automatic technology and it can work with no failures (Čarnogurská et al. 2015, Ondro et al. 2018). Pellets made by this way of production have stable quality and meet the standards and certifications. For good parameters of produced pellets is necessary also good quality of inlet raw material (Lazár et al. 2015). This all need to be paid and it is showed in

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price of these pellets. People, who want to save some costs for pellets from biomass, procure domestic device for pelletizing. Main part of domestic pelletizing device is, like in pellets factories, pellet mill. It is a type of mill or machine press used to create pellets from powdered material. Pellet mills are unlike grinding mills, in that they combine small materials into a larger, homogeneous mass, rather than break large materials into smaller pieces. Biomass mass is fed to a press where it is squeezed through a die having holes of the size required (normally 6 mm diameter, sometimes 8 mm or larger). The high pressure of the press causes the temperature of the wood to increase greatly, and the lignin plasticizes slightly forming a natural "glue" that holds the pellet together as it cools (Geffertová and Geffert 2016). Pellets made in domestic pellet mills have not so quality like pellets made in large pellets factories because used pressures are much lower.

The aim of this work is comparing of different energy and mechanical properties of pellets made from the same clean spruce sawdust in domestic condition and pellets made from biomass in large scale manufactory.

PRODUCTION OF WOOD PELLETS SAMPLES

Samples of wood pellets were produced in two ways:

- Sample A is from domestic production (fig. 1),
- Sample B is from factory production (fig. 2).

Fig. 1 Domestic device for pelletizing and sample A

Fig. 2 Factory device for pelletizing and sample B

Domestic production was similar to the production of wood pellets in domestic conditions, which is mostly used by smaller woodworking companies and carpenters, who have waste sawdust and shavings. A pellet press (fig. 1) with a theoretical production of 200 kg pellets per hour was used to produce the experimental samples, but under real conditions, only about 80-100 kg pellets per hour were obtained during experimental production. The sample A (Figure 1) was made from pure sawdust on this machine. Factory production of wood pellets was carried out at a specialized facility in an external laboratory (Figure 2, illustrative photo). The production line used has a production capacity of approximately 1 000 kg pellets per hour. Sample B (fig. 2) was formed on this machine from the same input material as for sample A. The input material came from spruce sawdust from a private sawmill located in northern Slovakia. The preparation of the base material consisted in adjusting the moisture to the required parameters. As the material delivered reached a moisture content of 8.11 %, in the case of a small domestic production of wood pellets, the sawdust needed to be dampened to about 15-17 %. In the case of the production of wood pellets on the production line, the humidity was controlled by the operator to approximately 12-15 % depending on the output quality of the wood pellets.

EXPERIMENT METHODOLOGY

These parameters of wood pellets were determined:

- Gross and calorific heating value - it was determined according to ISO 1716 by using of calorimeter LECO AC 500. A sample of wood pellet with weight about 1.0 g was burned in combustion vessel filled with oxygen to a pressure 31.0 bar. Combustion vessel was immersed in 2.0 dm3 of distilled water. During burning of sample was measured temperature increase of water. The calorific value was calculated from gross calorific value, moisture and hydrogen content.
- Amount of fines (F test) - fines hinder pellets from tumbling down to the in-feed auger, thus disturbing fuel feed to the boiler. Boilers are adjusted to burn pellets, but if fines arrive in the burning chamber, the flame may get too hot as fines particles burn faster than pellets. In the worst case the ash might sinter, which means that the burner must be cleaned after it has cooled down. The amount of fines should preferably be declared for each bulk delivery, and is measured at the final point in the factory production chain. Fines should preferably be less than 1% by weight. Amount of fines was measured in Lignotester (Fig. 3), where samples were placed in stream of air for 30 s with pressure of air 30 mbar. After this was weighted amount of fines under the sieve.
- Mechanical durability (DU test) - this is a measure of how well the pellets can stand handling. Every time pellets are handled, some of them break and all of them show some wear, which will increase the amount of fines. It was determined as quality parameter according to EN 15210 by using of special device – LignoTester (Fig. 3). There 100 g of pellets sample placed in stream of air for 60 s with pressure of air 70 mbar and after this was sample weighted.
- Moisture, volatiles, fixed carbon and ash content was determined by using of thermogravimetric analyzer (TGA, fig. 4). Measured by weight loss as a function of temperature in a controlled environment in a predefined atmosphere. The device consists of a computer and a muffle furnace that allows monitoring of up to 19 samples to be analyzed simultaneously. Empty cups on the samples are placed in carousel the furnace after selecting the method of analysis. The analysis method controls the carousel, furnace, and operating weights that gradually weigh all samples were placed

on the carousel. After weighing all the crucibles, is each a crucible is gradually adjusted for the operator of device for the sample application. Individual weights of samples are measured and saved automatically. When all the crucibles are loaded begins analysis. The loss in weight of each sample was monitored and the temperature of the oven is controlled according to the chosen analytical method. The percentage weight loss of each sample is known at the end of every step of the analysis. The device is easy to use with a software program Windows that allows analytical methods that can be designed to meet the most analytic applications according to current norms. The temperature, speed of rising temperatures and atmosphere are optional for each step.

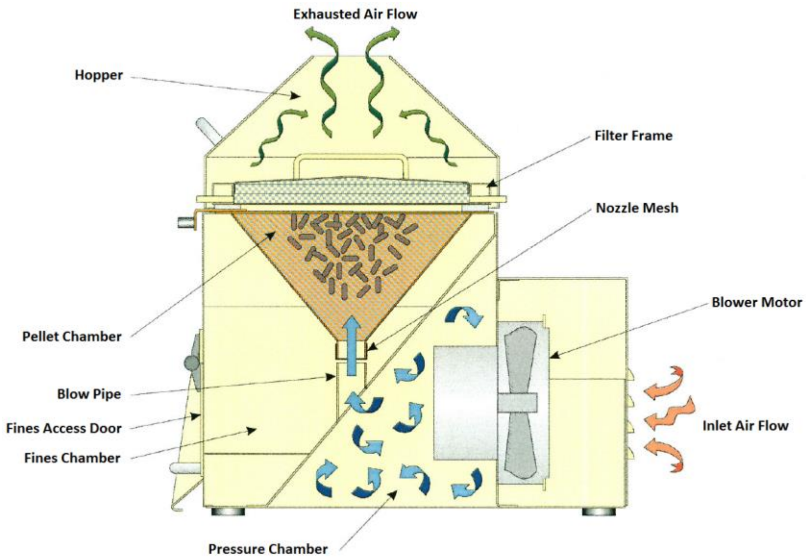

Fig. 3 LignoTester

Fig. 4 Thermogravimetric analyzer

RESULTS AND DISCUSSION

Table 1 shows the results of moisture content, gross and calorific heating value of wood pellets samples. Sample A achieved lower calorific value and gross calorific value than sample B, due to higher moisture content in sample A by other production methods.

The high calorific value difference could be also caused by lower pressure during the pelletizing and by lower compactness of sample A.

Tab. 1 The results of moisture content, gross and calorific heating value

	Moisture (%)	Gross calorific value (MJ/kg)	Calorific value (MJ/kg)
Sample A	7.33	18.7962	17.3121
Sample B	6.5	19.867	18.3626

Table 2 shows the results of amount of fines and mechanical durability of wood pellets samples. The results from the measured values showed that sample A has lower production quality than sample B. In the case of combustion in a conventional heat source for pellet burning, this causes wood pellets produced in the small pelletizer to be decomposed more rapidly during the feeding and during the combustion and thus can´t achieve the same heat output and efficiency of the heat source as the wood pellets produced in a large production line. During the operation of the heat source, this would result in higher pellet consumption and higher emissions.

Tab. 2 The results of amount of fines and mechanical durability

	F test		Amount of fines (%)	DU test		Mechanical durability (%)
	Mass before (g)	Mass after (g)		Mass before (g)	Mass after (g)	
Sample A	100.23	98.9	1.33	100.2	96.65	96.64
Sample B	100.89	107.86	0.03	107.87	107.34	99.51

Table 3 shows the results of moisture, volatiles, fixed carbon (FC) and ash content in wet and in dry state of wood pellets samples. Volatile and fixed carbon (FC) values are roughly identical due to the same input material - spruce sawdust. Ash content for samples A and B are also almost identical.

Tab. 3 The results of moisture, volatiles, fixed carbon (FC) and ash content in wet and in dry state

	Mosture (%)	Volatile (%)	FC (%)	Ash (%)	Volatile ($\%_d$)	FC ($\%_d$)	Ash ($\%_d$)
Sample A	7.33	75.56	16.55	0.45	81.66	17.89	0.48
Sample B	6.5	76.45	16.41	0.48	81.91	17.58	0.51

CONCLUSION

The difference between commercial and domestic wood pellets production is quite clear from the results obtained. In domestic conditions on small pelletizing presses, high pressing pressures and temperatures can´t be achieved, as in the case of the production of wood pellets on a production line with high production. The produced wood pellets differ mainly in qualitative mechanical parameters, when domestic wood pellets are rather decaying, thereby reducing the bulk density, which is negative in their combustion. However, unless the commercial use of wood pellets is anticipated and their domestic consumption is assumed, it is important to produce wood pellets in small pellet presses.

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