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CHARACTERISTICS OF PELLETS PRODUCED FROM SELECTED PLANT MIXES

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Summary. The article presents research results concerning production of pellets from mixes of selected plant materials. Depending on the composition of a plant mix used for pelleting, differences were observed as to the power consumed by an electric engine running a pelleting machine's working unit, in the range from 3.34 to 4.49 kW. On the basis of the conducted chemical analyses fat and cellulose contents were determined in particular plant mixes. Also, the amount of ash was determined remaining after the sample's combustion, which was about 1.8% for mixes I, II, III and about 2.3% for mix IV.

Key words: biomass, plant mixes, pellets, power consumption.

INTRODUCTION

Necessity of looking for renewable energy sources causes a growing interest in Poland in application of plant biomass for thermal energy production. It can be used for energetic purposes during direct combustion of solid biofuels as well as in the processing of fluid or gas biofuels. Development of these energy sources is also significant for an increase of independence and national energetic safety. However, compared to other energy sources, unprocessed biomass is a less useful energetic material [5, 14].

Problems connected with energetic biomass application can be solved by adequate plant materials' processing, significantly increasing their density and fuel value [3, 8, 13]. The most frequently used operations of plant material's processing into solid biofuels include: drying, pressing, shredding, pelleting, or forming into briquettes. Using densified biomass has a lot of advantages. The storage area can be greatly reduced, transport costs lowered, moreover it is possible to introduce full automation of combustion process [11].

Production of pellets and briquettes has become a trend that can turn out to be a crucial branch of agriculture. Considering a variety of biomass sources, from field plant crops, through waste materials in agriculture, agri-food industry, households and communal activities, to wooden waste in forestry, wood industry and cellulose-paper industry, this raw material is prospective not only for thermal energy production but also the possibility of development of the areas where it is produced and processed [9, 12, 15]. Application of plant origin waste materials such as post-harvest cereal debris, wooden waste (silvers, sawdust) etc. for production of pellets or briquettes will create a possibility of their effective exploitation and will promote the natural environment [16].

Production of pellets is one of the methods of biomass densification by mechanical pressure. Pellets are characterized by low moisture content (about 8%) and high density (above 600 $kg \cdot m^{-3}$), which is important especially during transport and storage [10]. Raw materials' densification capabilities depend on numerous physical factors, e.g. moisture, granulometric content, internal friction coefficient, temperature, looseness etc. [2, 7, 17]. Chemical content of plant materials is also significant. Plant origin materials usually contain cellulose, starch, proteins, resins, lignin, fats and waxes [4, 10, 11]. These substances undergo various physical and chemical changes influencing energy consumption during the process. For example, an increase of fibre content can cause an increase of energy consumption during densification, whereas fat content has an effect on a reduction of agglomerate's pressing resistances, however it also causes a decrease of the product's endurance properties [2, 4, 6].

The aim of the paper was a determination of power consumption by an electric engine running a pelleting machine's working unit during densification of various mixes prepared from selected plant materials. Moreover, a characteristics was determined of the pellets created from these mixes, including cellulose and fat content (elements which influence the pelleting process), as well as the amount of raw ash remaining after the tested samples' combustion.

MATERIALS AND METHODS

The tests were carried out on such plant materials as post-harvest fodder corn debris (straw with cobs, glumes), sawdust, wheat and oat ground grain as well as used edible oil (fritter waste). Plant materials were shredded with a H 111/4 shredder equipped with a hammer shredding unit and sieves of 3 mm hole diameter. Then, particular plant materials were combined with oil and mixes were created of constant mass – 10kg – and variable percentage of the included elements. The produced mixes were pelleted using a pelleting machine of the RMP 250 type with a densifying unit equipped with two rolls of 95 mm in diameter and 45 mm width as well as a ring matrix of 3.5 mm hole diameter and the working width of 45 mm.

The energy consumption during pelleting was determined using the converter Lumel PP83 equipped with a computer testing stand, recording results of measurements. On the basis of the conducted chemical analysis cellulose and fat contents were determined in the produced granulate as well as the amount of raw ash obtained after combustion of pellets. The chemical analyses were carried out in the Central Apparatus Laboratory of the University of Life Sciences in Lublin. The statistical analysis of the test results was conducted by the method of mono-element variance analysis and Tukey's trust intervals, at the assumed significance level $\alpha = 0{,}05$

MATERIAL FOR RESEARCH

Table 1 presents contents of the plant mixes prepared for pelleting. The percentage of particular elements in the mixes ranged from 10% for corn glumes (mix III) to 45% for sawdust (mix IV). Most often the contents of materials used in the tested mixes ranged from 15% to 25%. Only the content of oil used as an adhesive was 5% for all the mixes. As a result of the prepared mixes' densification, pellets were obtained of approximately equal diameter (about 4mm) and different lengths, from a couple to several millimeters (Fig. 1).

Table 1.

No.	Material	Mix I (%)	Mix II (%)	Mix III (%)	Mix IV (%)
1	Ground oats	-	20	25	25
2	Ground wheat	40	20	25	25
3	Corn glumes	20	15	10	-
4	Corn cobs and straw	20	15	15	-
5	Sawdust	15	25	20	45
6	Oil	5	5	5	5

Fig. 1. Pellets produced from the tested plant mixes

RESULTS OF RESEARCH

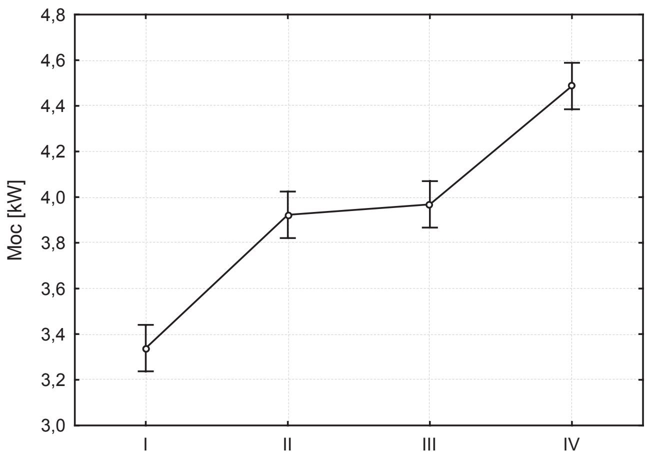

Fig. 2. Changes of power consumed by the pelletiung machine's engine depending on type of mix used for pellets production

The values of power consumed by the electric engine running the pelleting machine's working unit during the densifying of particular plant mixes are presented in Fig. 1. The lowest power consumption, on average 3,34 kW, was recorded during the granulation of mix I. A significantly higher power consumption was recorded for mixes II and III: 3,92 and 3,97 kW, respectively. And the highest power consumption was recorded for mix IV and it reached on average 4,49 kW.

Comparing power consumption values for particular plant mixes it should be pointed out that mix I, which was characterized by the lowest power consumption value, consisted mainly of field crops and contained little sawdust. And in case of mixes II and III, in which the proportion of field crops was lowered and more sawdust added, power consumption increased by about 34% compared to power consumption for mix I and about 14% compared to the power consumed for mixes II and III.

A statistical analysis of the obtained research results showed significant differences among the power values consumed by the engine running the pelletin machine's working unit depending on the kind of mix used for pellet production (Tab. 2). Considering the percentage of particular plant materials in the tested mix the greatest differences were observed between mixes I and IV (3,34 i 3,97 kW), and II and IV (3,92 i 4,49 kW). However, no statistically significant differences were found between mixes II and III (3,92 i 3,97 kW).

Table 2. Tukey test's results at the 95% trust interval for power consumed by a pelleting machine's engine depending on the applied plant mix

No.	Mix	Value of the consumed power (kW)			
		3,34	3,92	3,97	4,49
1	I		0,000008	0,000008	0,000008
2	II	0,000008		0,924807	0,000008
3	III	0,000008	0,924807		0,000008
4	IV	0,000008	0,000008	0,000008	

The conducted chemical analysis showed that for particular plant mixes fat content changed, from 5.2% for mix I to 7.5% for mix II (Fig. 3). For mixes III and IV the content of this element was similar and reached about 6%. Cellulose content for the prepared mixes remained in the range from 17.6% for mix III to 22.7% for mix II. For mixes I and IV cellulose content was 17,9 i 19,3%, respectively. The amount of ash after samples' combustion was practically the same for mixes I, II and III and reached about 1.8%. And the largest amount of ash – on average 2.3% – was observed for mix IV.

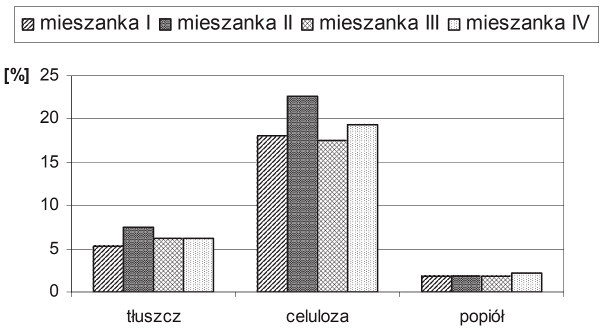

Fig. 3. Contents of fat, cellulose and raw ash in plant mixes used for pellet production

CONCLUSION

On the basis of the conducted research and obtained results it is possible to draw the following conclusions:

1. The value of power consumption during the densification process is considerably affected by contents of particular elements in plant mixes used for pelleting. The lowest power consumed by a pelleting machine's engine was observed for mix I (3.34 kW) consisting of ground wheat (40%), post-harvest corn debris (glumes 20%, straw and corncobs 20%), sawdust (15%) and plant oil (5%). The highest power consumption was observed for mix 1V (4,49 kW), with the following contents: ground oats and wheat 25%, each, sawdust 45% and oil 5%.
2. A statistical analysis of research results showed statistically significant differences between power consumption during the pelleting and contents of the applied plant mix. Hence it was proved that an increase of ground wheat and sawdust in plant mixes results in an increase of power consumption from 14 to 34% compared to the power consumed for mixes with lower contents of these elements.
3. A chemical analysis showed the greatest differences in fat contents between mixes I and IV (5,2 i 7,5%), and for cellulose content between mixes II i III (7,6 i 22,7%). The largest amount of ash after combustion was recorded for mix IV (2.3%) whereas for the remaining mixes the amounts of ash were practically the same and reached the average value of 18%.

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