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The usefulness of briquettes and pellets from selected plant materials for energy purposes

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Summary. This article presents the results of research on the calorific value and heat combustion of briquettes and pellets made from various plant materials. The calorific value of briquettes and pellets from wheat straw amounted to 14,958 MJ·kg^{-1} and 15,960 MJ·kg^{-1}, respectively, and from rye straw 15,865 MJ·kg^{-1} and 16,627 MJ·kg^{-1}, respectively. A slightly smaller calorific value was reported for briquettes and pellets made from maize straw: 14,134 MJ·kg^{-1} and 15,868 MJ·kg^{-1}, respectively. The highest calorific value (19,284 MJ·kg^{-1}) was reported for pellets made from olive cake. Statistical analysis showed significant differences between results obtained for the combustion heat of briquettes made from wheat straw, rye straw and maize straw. Significant differences were also observed between the combustion heat of pellets made from olive cake and pellets made from the three tested varieties of straw.

Key words: energetics, straw, briquettes, pellets

INTRODUCTION

Plant production can be a significant source of renewable materials for industry. Increasing its share in the production of energy benefits all citizens, because it helps to save fossil fuels and reduce the emission of carbon dioxide into atmosphere, which is, among other things, responsible for intense climate changes. The main by-product of plant production on farms is the straw of cereals and other cultivated plants. One of the ways of managing the surplus of straw is its utilization in energetics [Skonecki et al. 2011].

The moisture of biomass derived from agriculture assumes a wide range of values. It depends on the variety, maturity and part of the plant, and on the weather conditions. Wheat straw and rye straw have lower moisture than maize straw. In addition, the moisture of maize straw varies significantly depending on the part of the plant [Szymanek, Kachel-Jakubowska 2010].

In comparison with other commonly used energy carriers, stray in its unprocessed form is a rather burdensome energy material. This is because it is a heterogenic material, of lower energetic value, particularly when related to a unit of volume, in comparison with conventional energy carriers. In order to standardize the straw and improve its usefulness for energy purposes it is necessary to increase its volume weight, which can be done through densification of the loose straw. The densification is achieved through kneading (straw pressing). To facilitate the manipulation of straw even further, small elements (briquettes, pellets) are produced: durable rolls, bales, or other forms [Adamczyk et al. 2006, Fiszer 2009, Gradziuk 2006, Gradziuk and Kościk 2007].

In Poland, where ca 95% of electric energy is produced from coal, biomass assumes particular importance, which is reflected in the currently binding legislation. In order to facilitate the energetic utilization of biomass (transport, storage and combustion), it is processed into so-called solid biofuels, among which briquettes and pellets are of greatest importance [Bakhareva 2008]. Pellets are made by compressing the material at high pressure, without using any gluing chemical substances. They have a round cross-section with a 6-30 mm diameter and 10-50 mm length. Straw of all cereals as well as meadow grasses can be used to produce them. The growth in the use of pellets for energy purposes offers a great chance to increase the production of biomass used for making them. The obtained pellets are a fuel which can be useful both for individual heating systems and collective heating systems. They are thus particularly useful in small installations, such as boiler-houses or fireplaces in detached houses [Niedziółka et al. 2011, Hejft 2011]. Of great help are new technical solutions which make it possible to transform biomass into various forms of energy more and more efficiently and facilitate its common use.

The necessity of obtaining more and more biomass by energy plants gives farmers an opportunity to gain an additional source of income. All they need to do is

collect the straw on the fields using any kind of baler and then sell it to a company which organizes the production of biomass to satisfy the needs of energetic.

MATERIAL AND METHODS

The aim of the research was to determine the combustion heat and calculate the calorific value of briquettes and pellets made from various materials derived from agriculture. The obtained results are supposed to show the usefulness of briquettes and pellets from various plant materials in the co-combustion with coal in professional electric power stations in Poland.

The material for research was obtained from BIOENERGIA INVEST S.A., a stock company in Dobre Miasto. The research was conducted on cylindrical briquettes with ca 70 mm diameter and 10-100 mm length, and pellets with 25 mm diameter and random length. They were characterised by the so-called "fruit drop" structure (a row of interconnected, easily separable tablets of 10-15 mm length). We examined briquettes and pellets made from what straw, rye straw and maize straw, and pellets made from olive cake. After averaging samples, their moisture was determined using gravimetric method.

The calorific value and combustion heat of briquettes and pellets were determined in accordance with the Polish norm PN-ISO 1928: 2002. The measurements were repeated three times for each test. The differences in calorific values did not exceed the difference specified in the procedure between two markings and amounting to 200 $kJ \cdot kg^{-1}$.

The results were analyzed statistically. Variance analysis and significance tests were conducted at the level of $\alpha = 0.05$, separately for briquettes and pellets, using STATISTICA 6.0 program.

RESULTS AND DISCUSSION

The results of research on the calorific value and combustion heat of briquettes and pellets made from wheat straw, maize straw and rye straw, and of pellets made from olive cake, are presented in table 1 and in figure 1.

It should be stressed that the calorific value of briquettes and pellets from agricultural biomass is extremely significant for professional energetics because this index influences the price of the product delivered to the electric power station. The nominal calorific value of the material established by Polish electric power stations amounts to

Table 1. Calorific value and combustion heat of briquettes and pellets made from various plant materials

Material tested		Mass of sample before drying [g]	Mass of water [g]	Dry mass [g]	Relative moisture [%]	Enthalpy of combustion [$MJ \cdot kg^{-1}$]	Calorific value [$MJ \cdot kg^{-1}$]	Combustion heat [$MJ \cdot kg^{-1}$]
Briquettes	from wheat straw	10	0,742	9,258	7,42	16,458	14,958	15,237[a]
	from rye straw	10	0,697	9,303	6,97	17,354	15,865	16,144[c]
	from maize straw	10	0,752	9,248	7,52	15,636	14,134	14,460[b]
Pellets	from wheat straw	10	0,722	9,278	7,22	17,455	15,960	16,195[a]
	from rye straw	10	0,794	9,206	7,94	18,14	16,627	16,699[a]
	from maize straw	10	0,723	9,277	7,23	17,363	15,868	16,108[a]
	From olive cake	10	0,859	9,141	8,59	20,813	19,284	19,025[b]

Different letters in the index indicate major differences between the features tested (separately for pellets and briquettes) at the significance level $\alpha = 0,05$

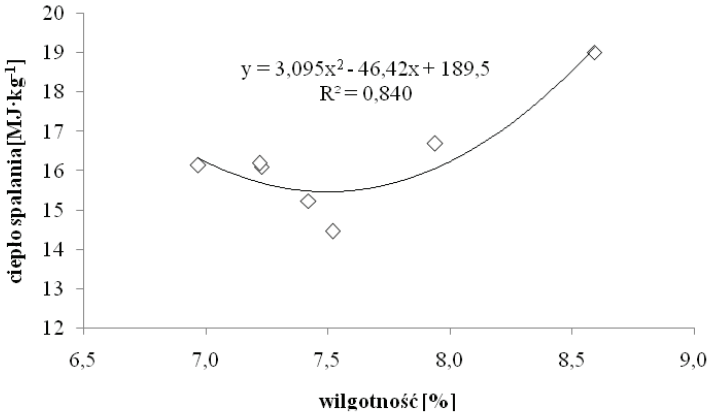

Fig. 1. Combustion heat of tested briquettes and pellets at specified moisture values

14,3 GJ·t^{-1}. If the producer of biomass who is contract-bound with an electric power station delivers material of lower calorific value than the established one, s/he will obtain a lower price, and vice versa.

The calorific value of briquettes and pellets made from wheat straw amounted to 14,958 MJ·kg^{-1} and 15,960 MJ·kg^{-1}, respectively, while the value for rye straw amounted to 15,865 MJ·kg^{-1} and 16,627 MJ·kg^{-1}, respectively. A slightly smaller calorific value was determined for the briquettes and pellets made from maize straw; it amounted to 14,134 MJ·kg^{-1} and 15,868 MJ·kg^{-1}, respectively. The highest calorific value (19,284 MJ·kg^{-1}) was determined for pellets made from olive cake.

Statistical analysis has shown considerable differences between the results concerning combustion heat of briquettes made from wheat straw, rye straw and maize straw. Significant differences were observed between the combustion heat of pellets made from olive cake and the combustion heat of the pellets made from the three tested varieties of straw.

CONCLUSIONS

1. The combustion heat of pellets and briquettes depends on the plant material they are made from.
2. Significant differences were observed concerning the combustion heat of briquettes from wheat straw, rye straw and maize straw.
3. Significant differences were observed between the combustion heat of pellets made from olive cake and pellets made from wheat straw, rye straw and maize straw, while no significant differences in combustion heat were observed among the pellets made from the three tested varieties of straw.
4. The highest value of combustion heat, amounting to 19,025 MJ·kg^{-1}, was observed for pellets made from olive cake.
5. Briquettes and pellets made from wheat straw, rye straw and maize straw, and from olive cake meet all the requirements concerning calorific value as specified by professional electric power stations.

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PRZYDATNOŚĆ BRYKIETU I PELETU Z WYBRANYCH MATERIAŁÓW ROŚLINNYCH NA CELE ENERGETYCZNE

S t r e s z c z e n i e. W pracy przedstawiono wyniki badań wartości opałowej i ciepła spalania brykietów i peletów wykonanych z różnych materiałów roślinnych. Wartość opałowa brykietów i peletów ze słomy pszennej wynosiła odpowiednio: 14,958 MJ·kg^{-1} i 15,960 MJ·kg^{-1}, natomiast ze słomy żytniej odpowiednio: 15,865 MJ·kg^{-1} i 16,627 MJ·kg^{-1}. Nieco mniejszą wartość opałową stwierdzono dla brykietów i peletów wykonanych ze słomy kukurydzianej, która wynosiła odpowiednio: 14,134 MJ·kg^{-1} i 15,868 MJ·kg^{-1}. Najwyższą wartość opałową (19,284 MJ·kg^{-1}) stwierdzono dla peletów z wytłoków oliwki. Analiza statystyczna wykazała istotne różnice między wynikami dotyczącymi ciepła spalania brykietów ze słomy pszennej, żytniej i kukurydzianej. Istotne różnice wystąpiły również między ciepłem spalania peletów z wytłoków z oliwki oraz peletów wykonanych z trzech badanych rodzajów słomy.

S ł o w a k l u c z o w e: energetyka, słoma, brykiety, pelety.