[1.]Georgeta GĂGEANU, [2.]Iuliana GĂGEANU, [3.]Dan CUJBESCU, [4.]Ioan Cătălin PERSU

EXPERIMENTAL RESEARCHES FOR DETERMINING THE PHYSICAL-CHEMICAL PROPERTIES OF BIOMASS PELLETS

[1-4.] INMA Bucharest, ROMANIA

Abstract: Human activity will always require the existence of a large volume of energy to support it. Due to climate change and the rapid depletion of conventional fuels, it is necessary to use renewable sources to provide the necessary energy. Biomass heating is the oldest and most well-established form of energy supply in the world, being intrinsically linked to the development of the human race. However, it was made redundant by the high energy density of fossil fuels, and its application in modern energy systems, especially in industrialized countries, has until recently been declining. A renewed interest in biomass-based energy systems comes from a variety of reasons. They are dominated by the interest in reducing greenhouse gas emissions, the emergence of new efficient biomass conversion technologies, as well as rising prices of fossil fuels. By pelleting, it is important preserve or enhance the physical-chemical properties of biomass that make this type of biofuel suitable for large scale use. The article presents a series of experimental researches in the field of solid biofuels, namely pellets from biomass for determining their physical-chemical properties, determinants for their use as solid biofuels.
Keywords: biomass, pelleting, calorific power, volatile matter

INTRODUCTION

The need to limit the use of conventional (fossil) fuels and replace them with fuels obtained from renewable energy has led to the intensification of researches in the field of obtaining biofuels from renewable energy such as biomass (Mani et al., 2003; Tabil et al., 2011). The benefits of biofuels compared to traditional fuels aim to lead to greater energy security, lower environmental impact, financial savings and socio-economic aspects related to the rural sector.

Given that biomass is the most abundant renewable resource in the world being represented by any plant component, including manure and sewage sludge. Under proper processing, freshly harvested biomass can be converted into products similar to natural gas or liquid or solid biofuels (Stelte, 2012).

Biomass heating is the oldest and most well-established form of energy supply in the world, being intrinsically linked to the development of the human race. However, it was made redundant by the high energy density of fossil fuels, and its application in modern energy systems, especially in industrialized countries, has until recently been declining.

A renewed interest in biomass-based energy systems comes from a variety of reasons. They are dominated by the interest in reducing greenhouse gas emissions, the emergence of new efficient biomass conversion technologies, as well as rising prices of fossil fuels.

Except in cases where direct combustion is appropriate, crude biomass requires the conversion into solid, liquid or gaseous fuels that can be used to produce heat, electricity and as fuel for vehicles. This conversion is accomplished through a series of physical, biological, thermal and chemical processes (Ion, 2006).

In order to obtain solid biofuels that can replace fossil fuels such as coal from biomass is necessary to undergo a compaction process, such as pelleting. The process of producing the pellets involves subjecting the biomass material (sawdust from woody biomass, grinded agricultural biomass or combinations between the two types, with or without using additives) to high pressures and forcing it to pass through the cylindrical orifices of a flat or cylindrical die. Due to the temperature and the friction forces that develop inside the machine, the biomass "fuses", resulting in compact and uniform pellets (Artemio et al., 2018; Smaga et al., 2018, Wu et al., 2011).

Pelleting materials of forest or agricultural origin have the following advantages: a considerable reduction in the waste of wood material; higher capitalization of the by-products of agriculture and forestry; reduction of handling and storage costs.

By pelleting, it is important preserve or enhance the physical-chemical properties of biomass that make this type of biofuel suitable for large scale use. This paper shows a series of experimental researches conducted on biomass pellets to determine their physical-chemical properties, in comparison with those of the raw material.

MATERIAL AND METHOD

For conducting the experimental researches, sawdust and pellets obtained from fir tree, oak and alder sawdust were used. All sawdust samples had the same granulation (2 mm) and all pellets were obtained in the same conditions (using a single pellet device with an 8 mm diameter die, at 80°C). Table 1 shows the samples used for experiments.

Table 1. Samples for analysis

Sample no.	Type
1	Fir sawdust
2	Fir pellets
3	Oak sawdust
4	Oak pellets
5	Alder sawdust
6	Alder pellets

Figure 1. Sawdust and pellet samples used for experiments

The following equipment were used during the researches, presented in Table 2.

Table 2. Equipment used for determining the physical-chemical properties of pellets

Equipment/type	Measure domain / division
Precision weighing scales /AW 220 M, with self-calibration (Shimadzu - Japan)	0÷200 g / 0.1 mg
Furnace with temperature adjustment / -UFE 500 (Memmert - Germany)	0÷260°C / 1°C
Calorimeter /CAL 2k (DDS Calorimeters - South Africa)	0.001 MJ kg^{-1}
Calcination oven, with P 320 controller (Naberterm - Germany)	0 ÷ 1400°C / 10°C

All biomass and pellet samples for analysis were prepared according to the specifications found in standard ISO 14780:2016 – Solid biofuels: Sample preparation.

METHODS OF ANALYSIS USED

— Moisture content

Moisture content (%) was determined on a wet basis, according to the method described in standard ISO 18134-1:2015 – Solid biofuels – Determination of moisture content – Oven dry method – Part 1: Total moisture – Reference method.

— Energy content

The energy content (MJ/kg) of pellet samples was determined using the calorimeter bomb, according to the specification found in ISO 18125:2016 standard – Solid biofuels – Determination of calorific power.

— Ash content

The ash content (%) of sawdust and pellets samples was determined using the calcination oven, at 550°C, according to the provisions of standard ISO 18122: 2015 – Solid biofuels – Determination of ash content.

— Volatile matter

The content of volatile matter (%) was determined by introducing the samples at 900 °C in the calcination oven, according to the provision found in standard ISO 18123: 2015 – Solid biofuels – Determination of the content of volatile matter.

— Sawdust and pellet density

Sawdust density (kg/m³) was determined using a cylinder that has a known volume and a precision scale for weighing the samples, according to the provisions of standard ISO 17828:2015 – Solid biofuels – Determination of bulk density.

Pellet density was determined by giving the pellet samples a cylindrical shape by sanding the irregularities resulted from the pelleting process and weighing each sample.

Figure 2. Aspect during the experiments

RESULTS

Using the methods previously mentioned, after conducting the analysis, the following results were obtained, presented in table 3.

Table 3. Results obtained from the analysis of pellets

Sample no.	Moisture content [%]	Energy content [MJ/kg]	Ash content [%]	Volatile matter content [%]	Density [%]
1	13	16.589	4.22	73.50	142.18
2	9.21	15.981	4.18	72.58	1001.47
3	13	15.788	5.21	73.48	184.75
4	9.53	16.021	5.18	73.42	1124.31
5	13	15.521	5.88	74.23	178.91
6	9.86	15.470	5.76	72.81	1024.31

It can be observed that the moisture content of pellets registered values ranging between 9.21 % and 9,86 % for pellets obtained, indicating that coniferous sawdust loses water more easily during the pelleting process.
The moisture obtained for the pellets is under 10%, indicating good storage combustion attributes.
Calorific power registered small increases for all samples after compaction, while volatile matter had small decreases for pellets compared with sawdust, indicating that volatiles are released during the process, due to the high temperature used. The ash content of pellets had small variations compared to sawdust.
Bulk density was found to increase greatly (7.04 times for fir, 6.08 times for oak and 5.72 times for alder sawdust).

CONCLUSIONS

The experimental researches showed that the compaction of sawdust had an overall beneficial effect, mainly on the stability of the biomass, storage characteristics and energy content, but also gives a solution for ensuring quality solid biofuel. Therefore, this study has shown that the pelleting process is a represents a good solution for valorizing the residues from silviculture, tree grooming, etc.

Acknowledgement
This work was supported by the Romanian Research and Innovation Ministry, through NUCLEU Programme, Project "Researches on the intensive polyculture growth of fish and the complex valorization of aquatic bioresources (plants)", code PN 19 10 02 03, contract no. 5N/07.02.2019.

Note:
This paper is based on the paper presented at ISB–INMA TEH' 2019 International Symposium (Agricultural and Mechanical Engineering), organized by Politehnica University of Bucharest – Faculty of Biotechnical Systems Engineering (ISB), National Institute of Research–Development for Machines and Installations Designed to Agriculture and Food Industry (INMA Bucharest), Romanian Agricultural Mechanical Engineers Society (SIMAR), National Research & Development Institute for Food Bioresources (IBA Bucharest), National Institute for Research and Development in Environmental Protection (INCDPM), Research-Development Institute for Plant Protection (ICDPP), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and "Food for Life Technological Platform", in Bucharest, ROMANIA, between 31 October – 1 November, 2019.

References

[1] Artemio C.P., Maginot N.H., Serafin C.U., Rahim F.P., Guadalupe R.Q.J., Fermin C.M., (2018), Physical, mechanical and energy characterization of wood pellets obtained from three common tropical species. PeerJ 6:e5504; DOI 10.7717/peerj.5504;
[2] Ion V. I., Ion D. I., (2006) Consideraţii teoretice energie, Universitatea „Dunărea de Jos" din Galaţi, nr. 7/2006;
[3] Mani S., Tabil L.G., Sokhansanj S. (2003), An Overview of Compaction of Biomass Grinds, Powder handling & processing, vol. 15, no.2, pp. 1-9;
[4] Smaga M., Wielgosinski G., Kochanski A., Korczak K. (2018), Biomass as a major component of pellets, Acta Innovations, no. 26, pp. 81-92;
[5] Stelte W. (2012), Guideline: Storage and Handling of Wood Pellets, Report, Danish Technological Institute;
[6] Tabil L., Adapa P., Kashaninejad M. (2011) In biomass feedstock pre-processing: densification, Biofuel's Engineering Process Technology, M. A. Dos Santos Bernardes, Ed., pp. 439–464, InTech, NY, USA;
[7] Wu M.R., Schott D.L., Lodewijks G. (2011), Physical properties of solid biomass, Biomass and bioenergy 35, pp. 2093 – 2105;
[8] ISO 14780:2016 – Solid Biofuels. Sample preparation;
[9] ISO 18134-1:2015 - Solid biofuels - Determination of moisture content - Oven dry method - Part 1: Total moisture – Reference method;
[10] ISO 18125:2016 – Solid biofuels – Determination of calorific power.
[11] ISO 18122:2015 - Solid biofuels - Determination of ash content;
[12] ISO 18123:2015 - Solid biofuels - Determination of the content of volatile matter;
[13] ISO 17828:2015 - Solid biofuels - Determination of bulk density.

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
ISSN: 2067-3809