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EXPERIMENTAL RESEARCHES ON THE BENEFITS OF ADDITIVE ADDITION TO AGRICULTURAL BIOMASS PELLETS

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Abstract: The manner in which we obtain our energy represents one of today's priorities in the context of climate changes and of increased levels of pollution worldwide. The orientation towards renewable energy was first triggered by the inevitable and rapid depletion of fossil fuels, but also by a more active involvement of authorities in problems related to environmental protection. Biomass is one of the most important sources of renewable energy and has the advantage that after an adequate processing, it can be used in the same purposes as fossil fuels. The paper presents a series of experimental researches for assessing the benefits of introducing additives (corn starch) in the recipes for obtaining pellets from agricultural biomass.
Keywords: agricultural biomass, pellets, additives, renewable energy

1. INTRODUCTION

Biomass is the first source of energy on earth that was used by humans, except for solar energy. This began when man first discovered fire and realised that he can produce heat by burning wood. This way, biomass was the most known source of energy until the industrial revolution and man started to use fossil fuels to fulfil the more and more extensive energy needs. Unfortunately, our planet cannot transform and produce energy in the form of fossil fuels as fast as humans consume it. Therefore, it became imperative to find new ways to produce energy for everyday use. For this, man turned again towards biomass, as its advantages were already known. Biomass is available on every continent and it can be easily accessed or produced and if processed correctly, it can be used in the same manner and for the same applications as fossil fuels.[1,2,11]

One of the most common ways to process biomass is to transform it into solid biofuels, namely pellets and briquettes, through compression. Pellets represent the biofuel that can be produced from wood or agricultural waste. They are cylindrical granules of standard sizes between Ø5...8 mm with variable length of approximately 20-50 mm. They have increased mechanical resistance and good combustion characteristics. The pelleting process offers a real possibility of valorising the biomass potential.

Pellets can be obtained from wood processing waste, agricultural residues or from energetic plants. Pellets are a non-polluting fuel because from their combustion there are no harmful emissions. The mass of one m^3 of pellets weighs approximately 650-700 kg and produces around 3250 kWh of energy.[3]

The main advantages of compressing biomass are:

— Increasing the density of compressed material (from 80-150 kg / m^3 for straws or 200 kg / m^3 for sawdust to up to 600-700 kg / m^3 for pellets);
— A higher calorific value and a homogeneous structure of densified products;
— A low moisture content (lower than 12%);
— Improved storage characteristics;
— Extending the usage period of biomass materials.

Understanding some of the major chemical changes that take place during processing of biomass can be useful in understanding their compaction behaviour. As the densification of biomass is coupled with process variables like temperature, pressure, die geometry and mechanisms of densification changes in these variables will bring about significant changes in the chemical composition of the biomass by the mechanisms known as interaction reactions.[2,4] Besides the variables of the process, the use of an additive for the particles of biomass could have a positive effect on the resistance of pellets. Starch, proteins, fibers, fat / oil, lignosulfonate, bentonite, modified cellulose as well as other additives have proven to positively influence the overall quality of densified products. [5,6]

The paper presents a series of experimental researches conducted on pellet samples that were obtained with and without additives, in order to determine their influence on the most important quality attributes of pellets produced for energy purposes.

2. MATERIAL AND METHOD

Pellets were produced using three types of biomass materials, namely corn cobs, wheat straws and rapeseed stalks. To these materials, additives were added to determine their effect on the quality attributes of pellets obtained from the process. Six recipes were used to produce pellets – 3 without using additives and three using additives. The agricultural biomass materials used had the same characteristics for all the recipes tested.

The process of forming pellets consists in subjecting biomass to high pressures, period when particles are forced to agglomerate. Pellets were obtained using a large-scale ring die pelleting installation (figure 1), composed of the following main elements: plant chopper, dryer, feeding bunker, feeding augers (with motor), 2 pelleting chambers, blades for cutting the exiting pellets, pellet outlet, conveyors, cooling station etc.

The pellets were obtained by following the methodology:

- the biomass materials were grinded to the required dimensions;
- the grinded materials were then dried, homogenised and additives were added depending on the recipe used for compaction;
- the prepared material was introduced into the bunker that feeds the two ring die pelleting equipment from where it entered the actual densification process;
- resulting pellets fall from the outlet on the conveyor that takes them to the cooling area where they are left to reach room temperature in order to be packed.

Figure 1 – Ring die pelleting installation used for obtaining pellets

Table 1. Recipes used for obtaining pellets

Sample no.	Sample composition
1	50% corn cobs + 50% wheat straws
2	50% corn cobs + 50% rapeseed stalks
3	50% wheat stalks + 50% rapeseed stalks
4	48% corn cobs + 48% wheat straws + 4% corn starch
5	48% corn cobs + 48% rapeseed stalks + 4% corn starch
6	48% wheat stalks + 48% rapeseed stalks + 4% corn starch

The recipes used for obtaining pellets from agricultural biomass are shown in table 1. After the pellets were produced, the following quality attributes were verified:

- Moisture content – figure 2a (according to SR EN ISO 18134-1:2015. Solid biofuels - Determination of moisture content - Oven dry method - Part 1: Total moisture -- Reference method);
- Inferior calorific value figure 2b (according to SR EN ISO 14918:2010 - Solid biofuels. Determination of calorific value;
- Bulk density figure 2c (according to SR EN ISO 17828:2016 – Solid biofuels – Determination of bulk density);
- Ash content figure 2d (according SR EN ISO 18122:2016 – Solid biofuels -- Determination of ash content);

Figure 2 – Aspects during the experiments

3. RESULTS

The results registered after conducting the experiments are shown in table 2 and figure 3.

Table 2. Results after conducting the experiments of agricultural biomass pellets

Sample no.	Moisture content [%]	Inferior calorific value [MJ/kg]	Ash content [%]	Bulk density [kg/m^3]
1	9.54	16.175	7.98	587.65
2	9.78	16.203	8.12	576.91
3	10.42	16.150	7.68	558.66
4	9.21	16.240	8.02	609.28
5	9.27	16.335	8.22	601.28
6	9.89	16.240	7.55	621.52

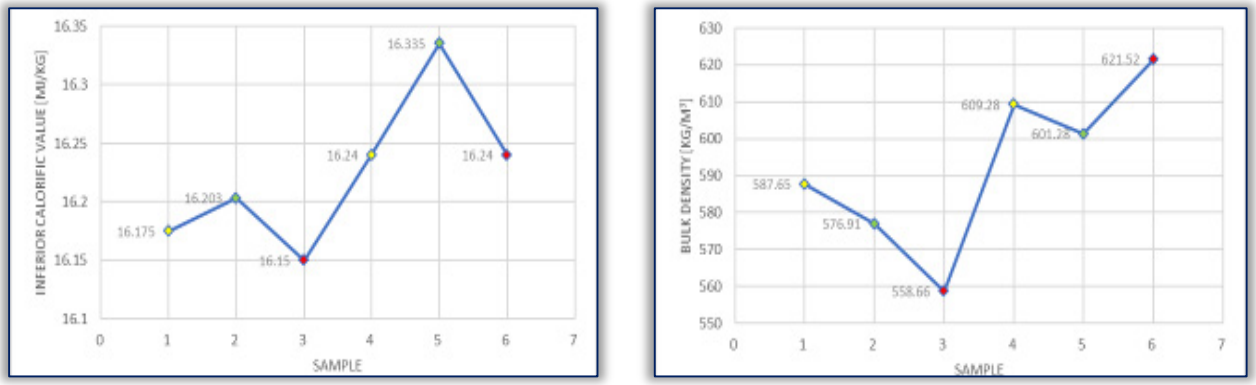

Figure 3 – Results from the experiments highlighting the benefits of additives in biomass pellets

4. CONCLUSIONS

After conducting the experiments on pellets obtained from agricultural biomass with and without additives, the following conclusions can be given:

- the addition of corn starch had a positive impact on the moisture content of pellets for all the samples;
- the ash content was higher in samples where corn starch was added, but the increase was not very significant;
- corn starch addition also had a positive impact on inferior calorific value registering increases in all samples;
- the biggest benefits were registered for bulk density, the addition of corn starch leading to more dense and compact pellets also with smoother surface area and less dust.

Biomass pelleting offers a real alternative to the use of fossil fuels for obtaining energy. Also, it represents a method of using all the agricultural biomass residues that otherwise would go to waste.

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