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RECYCLING OF CELLULOSIC WASTE IN THE ENERGY SECTOR

Mircea Viorel DRĂGAN
"Dunarea de Jos" University of Galati, Romania
e-mail: vdragan@ugal.ro

ABSTRACT

Biomass is one of the Earth's most abundant and precious resources. It offers not only food but also energy, materials used for construction, chemicals and much more. Biomass has always been used for generating energy since fire was discovered. The term of biomass covers a wide range of products, derived products and waste obtained from agriculture, forestry, including those derived from farming, domestic and industrial waste. This paper aims at investigating the main characteristics of the briquettes made out of wood, wood chips and sawdust.

KEYWORDS: biomass, briquettes, renewable energy

1. Introduction

Biomass is one of the Earth's most abundant and precious resources. It offers not only food but also energy, materials used for construction, chemicals and much more. Biomass has always been used for generating energy since fire was discovered. The term of biomass covers a wide range of products, derived products and waste obtained from agriculture, forestry, including those derived from farming, domestic and industrial waste [1]. The use of biomass for obtaining energy can bring significant social and economic benefits for both rural and urban areas. The current lack to access convenient energy sources is limiting the quality of life worldwide, especially in the rural areas of less developed countries. Biomass cultivation is an intense rural activity, which can lead to the increase in the job opportunities in the rural areas and can stop the migration from villages to cities. At the same time it offers the possibility to develop other rural industries [2]. Below are shown the future estimated costs of a kWh produced by various technologies including biomass (Table 1) [3].

Table 1. *The future estimated costs produced by various technologies* [1]

Technology	Costs in 2020 [Euro cent/kWh]	Cost Trend in 2050
Combined Production of Electricity and Heat in Large Units	< 3.2	limited reduction
Combined Production of Electricity and Heat in Small Units	4.0-5.6	sustained reduction
Photovoltaic	15.9-25.4	sustained reduction
Onshore Wind Turbines	2.4-4.0	reduction
Offshore Wind Farms	3.2-4.8	reduction
Biomass Energy	4.0-6.4	reduction
Fossil Fuel Energy	4.8-7.2	unknown
Nuclear	4.8-6.4	reduction
Combined Cycle with Gas Turbine (CCGT)	3.2-3.7	limited reduction
Combined Cycle with Integrated Coal Gasification (IGCC)	4.8-5.6	reduction

2. Experimental research

The main biomass source is wood. Besides wood, there is a wide variety of other resources like:

- crops for energy purposes;
- fast growing trees: poplar, willow, eucalyptus;

Waste:

- wood obtained from chopping the trees and from constructions;
- derived products:
- waste from wood processing (sawdust, shavings).

The technological technique of processing wood is shown in Figure 1 [4].

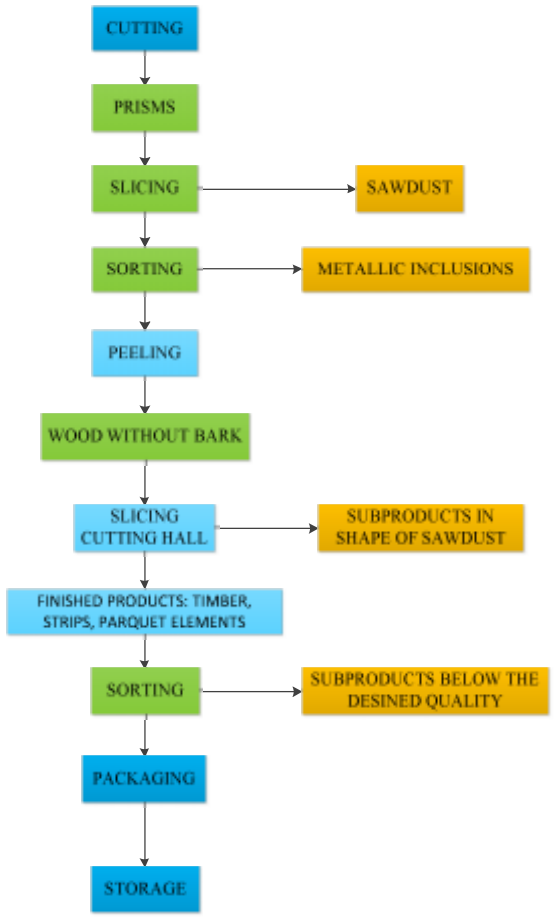

Fig. 1. *The technological process of wood processing*

Through briquetting the volume of sawdust is lowered so this eases the transportation and the storage. The experiments done on the briquettes have proven that they have a high caloric power of approx. 4200 kcal/kg. Also the heating costs are much lower in the case of using briquettes.

An important advantage of briquettes is that they can be easily lighted and the quantity of ash, as a result of their combustion is very little. If there are taken into account the costs and efforts for chopping and transporting the wood, the use of briquettes can be considered an economic and ecologic solution [5].

To conclude, the briquetting process consists of a production line with a waste sorter, heating system, sawdust dryer, briquetting machinery and auxiliary elements used in transportation. The stages of this process are as follows:

1. The first stage consists in the separation of sawdust from all other waste sawdust which may affect the proper functioning of the machinery.

2. It is followed by the operation of heating and drying the wastes, because the wet sawdust cannot be turned into briquettes. For this reason very useful assets are a heating system and a sawdust dryer, which give a maximum humidity of 17% (these are the optimal process conditions).

3. The final stage involves starting the briquetting machine, which turns the sawdust into briquettes; the machine presses the sawdust until the air from the wood chips is evacuated [6].

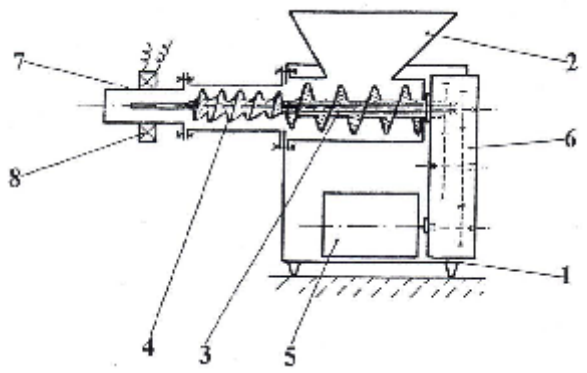

Fig. 2. *Screw briquetting plant scheme*

They do not contain additives as resins are naturally found in the briquettes and they have the scope to keep them compact, thus no additives are required. By using the wastes after the wood processing we obtain a valuable product, respecting and protecting nature [7].

Waste and environmental damage reduction after burning: after burning the briquettes, it remains very little ash, not more than 10% from the initial burned quantity; this ash can be used as soil.

Good price/efficiency ratio – heating costs based on sawdust briquettes is up to 60% less than the costs where petrol is used [8].

Higher efficiency than wood – due to the low water content and due to the material's density.

For wood, after combustion the ash quantity is up to 50% from the initial wood amount, compared to the sawdust briquette which is 10%.

High caloric value – sawdust briquettes have the caloric value between 4000-5500 Kcal/Kg, while for wood is between 1800-2000 Kcal/Kg.

Long combustion interval – higher than wood or charcoal.

Biomass can be considered as one of the most important renewable energy sources. In general terms, it can be said that biomass includes a wide range of materials such as: agricultural and technical plants, agricultural and forestry waste, etc. This paper aims at investigating the main characteristics of briquettes made out of wood, wood chips and sawdust [9, 10].

Different manufacturing companies show that sawdust briquettes are blocks of sawdust or organic solid blocks made out of wood chips. These are obtained at a high pressure and without extra additives and can be used for burning solid fuels, barbecue fire, water boilers, central heating, etc. The characteristics of the wooden briquettes are as follows (based on the European standards ONORM M7135 in Austria and DIN 51731 in Germany): operative humidity 4.6%, ashes mass 0.2%, amount of sulfur 0.01% and caloric power for the absolute dry mass of the briquettes 20370 kJ/kg [11, 12].

Main advantages of the briquettes in comparison with the massive wood:

- low ash content;
- lack of odour;
- high caloric value;
- long combustion period;
- high combustion temperature;
- combustion with sparks;
- no emission of toxic gases.

These sawdust briquettes can successfully replace brown coal, wood and natural gas.

For the tests there were used technological splinters and sawdust. The raw material was taken from the tenoning machine found in the university's laboratory. There were used two types of debris, wood chips and sawdust from spruce (Picea abies L) and beech (Fagus silvatica L). To prevent the blockage of the tenoning machine, for each type of raw material was extracted alittle sawdust (0.5×0.5 mm). In this way the technological splinters were defined as a fraction greater than 5×5 mm and the sawdust as a fraction between 0.5×0.5 and 5×5 mm.

The above values represent the sieve mesh sizes. The experiments were performed on a machine with two briquetting pistons for compression, as depicted in Figure 3.

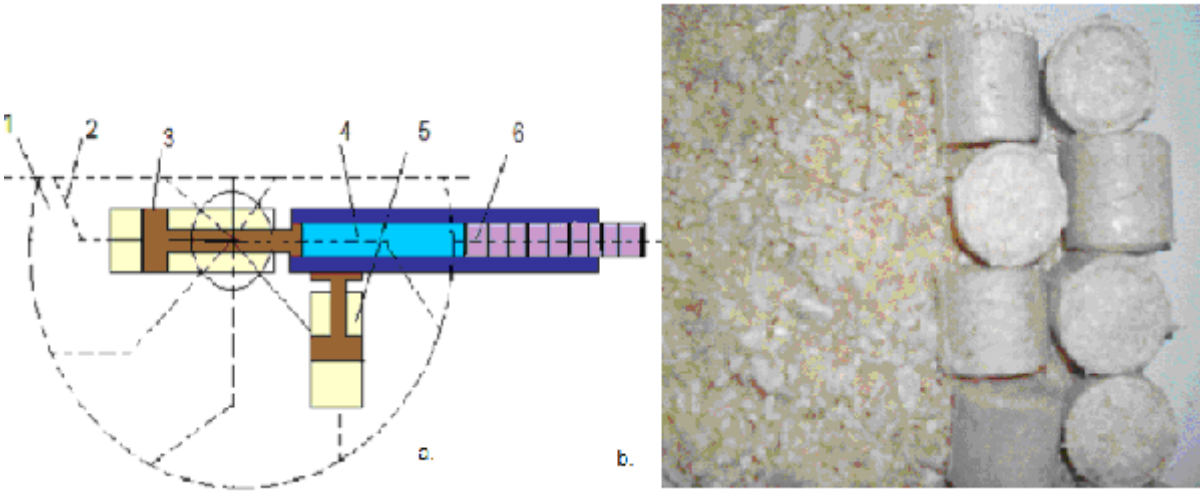

Fig. 3. *Briquetting machine (a) and briquettes (b): 1 – silo storage; 2 – pallet supply; 3 – main compression piston; 4 – extrusion canal; 5 – supply and compression of secondary piston; 6 – compressed briquettes*

The briquetting machine created the wooden briquettes by pressing with two hydraulic pistons, one for the power supply and the primary compression, and the second (the main one), for a strong compression.

Depending on the amount of the wooden chips introduced in the compression canal (Canal 4), there can be obtained briquettes of different lengths (range 20-90 mm), but with the same diameter (40 mm).

2.1. Briquettes density

Analysing the briquettes density (defined as the ratio between mass and volume), it can be observed

that different densities are obtained from different types of raw material.

The density of briquettes made out of spruce (837 and 878 kg/m^3) is less than the one obtained from beech wood (896 and 921 kg/m^3), this is due to the fact that the spruce's density (450 kg/m^3) is less than the beech's density (680 kg/m^3). There is no proportionality between these two densities, because the ratios are 1.86 and 1.95 (1.31 for spruce and 1.35 for beech).

This means that the spruce is a more compressible species, due to the porous structure.

On the other hand, it appears that the technological shavings are less compressible than the sawdust for both species and the reason is that dimensions of the raising coefficients are different.

2.2. Resistance to compression

The resistance to compression shows the consistency and compacting of the briquettes. There is no similar resistance in this field, only just some similarities with the massive wood, wooden fibres and concrete. On this basis was developed a new procedure to determine the resistance to compression, perpendicular to the briquette's length. The upper platen usually represents the main part of the machinery. The results are shown in Table 2.

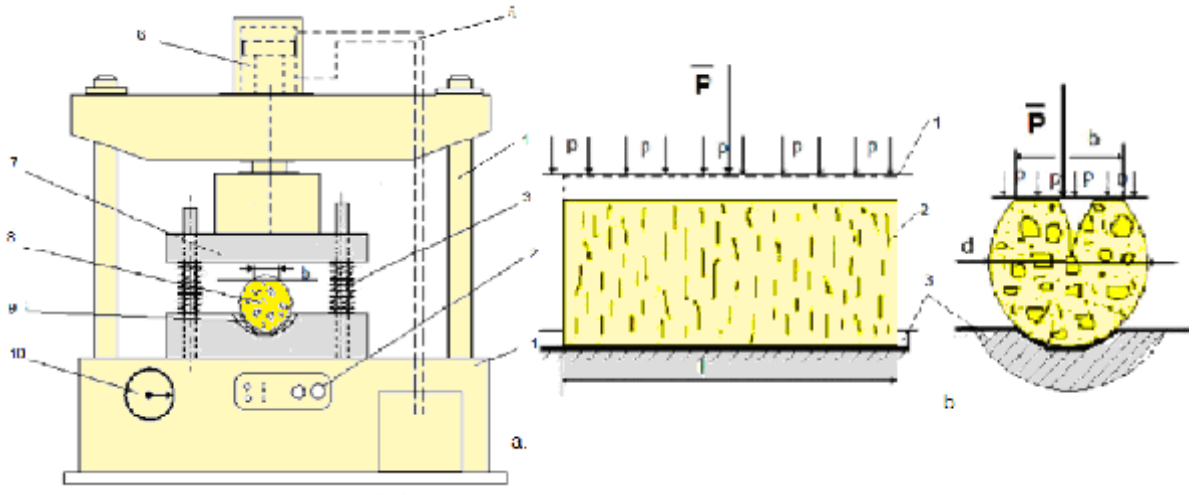

Fig. 3. *Determination of resistance to compression of briquettes – testing machine: 1 - frame; 2 - picture; 3 - springs; 4 - columns; 5 - pipes with hydraulic agent; 6 - cylinder-piston; 7- upper platen; 8 - briquette; 9 – lower platen; 1 0 – dial; – working principle: 1- area of force's application; 2 - briquette; 3 – lower platen*

Table 2. *Compressive strength of briquettes*

No.	Diameter	Force [N]	Dimensions of pressing plan [mm]		Compressive strength [N/mm^2]
			Length	Width	
1	Ø = 40 mm	3700	75	35	1.409
2		3300	74	32	1.393
3		1400	45	28	1.111
4		1600	38	30	1.403
5		1600	37	37	1.168
6		1500	30	26	1.923
7		1800	37	24	2.027
8		2100	26	37	2.182
9		2000	48	31	1.344
10		2200	62	30	1.182
Medium value of compressive strength [N/mm^2]					1.514

These characteristics determine the quality of the briquettes which were obtained using various machines (usually mechanical or hydraulic) and provide data regarding the fields where these can be used (stoves, central heating or power plants). The following research will be focused on the calorific value of briquettes and the wood biomass from which these were obtained. The importance of the studies carried out on this topic is given by the fact that briquettes are organic products made from biomass, gathered from the individual households, but mostly from wood processing companies.

3. Conclusions

In terms of biomass consumption in Romania are used different bio-fuels, as follows:

- wood-based fuels, used for industrial and steam boilers or for water heating used in various industrial heating processes;

- wood-based fuels, used in warm water boilers, with outputs of thermal power varying between 0.7 MW and Unit 7 MW;

- stoves and wood - stoves and/or various agricultural waste, used for individual heating and food warming, etc.

The advantages of using briquettes for heating our houses are numerous. Here are a few reasons why these should be used:

Cost by 80% less than the fossil fuel cost;

It is a renewable energy source;

Heating systems based on briquettes do not contribute to the decrease in the ozone level; they are considered to be in line with the Kyoto agreement regarding the gas emissions in the atmosphere;

Wood briquettes are easily transported (compact bags);

No trees are cut for the briquette's production; they are made out of the wood waste;

The heating systems based on briquettes are mostly automatic systems, which require very limited involvement from the operator;

Briquette's costs are stable and they are not subject to the foreign manufactures' increase;

Briquettes are burning at a very high temperature, eliminating very few remains (100 kg of briquettes produce only 0.5 kg of ash);

The American agency of environmental protection considers heat from wood briquettes to be one of the cleanest burnings and one of the most renewable energy source on the planet;

The main practical direction in research for improving the properties of wood briquettes is the activation of lignin from the wood particles, especially in the outer areas.

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