Analele Universităţii din Craiova. seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series) Vol. XLVI 2016

ASPECTS ON BIOMASS PELLETIZING

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Keywords: pelletizing, biomass, solid biofuels.

ABSTRACT

Biomass is one of the most common sources of renewable energy. The problem with biomass is that it hard to be used in its natural form, because it has low density and is hard to transport and stored, therefore it has to be processed. The pelletizing process offers a real possibility to valorise forestry and agricultural biomass residues by turning them into solid biofuel. The paper represents a synthesis of the machines and equipment existing worldwide at this moment for pelletizing biomass, as well as on the principles of producing pellets from biomass.

INTRODUCTION

Human activity overcharges the atmosphere with carbon dioxide and other emissions causing global warming, capturing heat, slowly increasing the planets' temperature and has a significant and harmful impact on human health, on the environment and on the climate. Increasing the supply of renewable would allow replacing energy sources with high carbon emissions and would lead to reducing global warming. [1]

Biomass, considered as renewable energy, is fundamentally different from other non-fossil energy sources (for example wing energy). It generates energy and secondary products similar to those of fossil resources. Biomass also has a very important use as food source and raw material for the industry, uses that need to be correctly correlated with its use for energy purposes and complying with sustainability principles. [9]

Biomass is the degradable part of products, waste and residues from agriculture, forestry and adjacent industries, as well as the biodegradable part of industrial and urban waste. Biomass comprises all forms of plant and animal material, grown on earth surface, in water or on water, as well as substances produced through biological development. Biomass represents the renewable resource most abundant on the planet. [2]

The main disadvantage of biomass is that it has very low density, leading to difficulties in the process of handling, transport, storage and respectively leads an increase of corresponding costs. Besides that, large variations in the material moisture can generate problems in the operation and adjustment of processes within burners or installation for producing energy where they are used. [3]

These shortcomings can be improved by drying and compressing (densifying) the material at very high pressures, thus obtaining wood solid biofuels with a uniform structure, such as pellets.

MATERIAL AND METHOD

Pellets represent the biofuel produced from wood waste, agricultural residues, energy crops, etc. they are cylindrical granules with standard sizes between Ø-5...8mm and with variable length of approximately 50 mm. They have high mechanical strength and very good combustion characteristics.

The process of producing pellets implies introducing grinded biomass in an equipment, at very high pressures and forcing it to pass through a round orifice in a special die/ when exposed to adequate conditions, biomass "merges" together, forming a solid mass. This process is not as "extrusion". [4]

Some types of biomass (mainly wood) form superior quality pellets naturally, while for other types of biomass may be necessary to introduce additives to serve as the "binder" that holds the material tied together in the shape of the pellet.

Nevertheless, the actual creation of pellets is only a small step in the general process of producing pellets the stages of the pelletizing operations are:

- raw material reception;
- drying the raw material;
- separating impurities and contaminants;
- grinding;
- conditioning;
- pelletizing;
- cooling pellets;
- separating pellets from wood dust (sieving);
- packing.

Each step must be done carefully so that the final product is to be of acceptable quality.

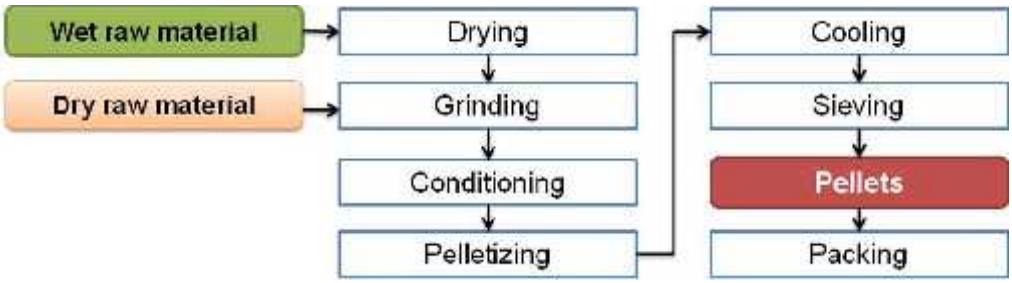

Fig. 1 – Pelletizing operation stages [16]

Biomass densification practically consists of two stages

- Compacting the raw material under pressure in order to reduce its volume and agglomerate the particles;
- The lignin in the wood is activated by the high pressures and high temperatures and "binds" (glues) biomass material.

RESULTS AND DISCUTIONS

The pelletizing operation is achieved by using special equipment with one die and one or more pressing rollers, two dies or one die and a corrugated pressing body. The most common ones have one die and at least two pressing rollers.

The pelletizing machines are usually comprised of the following main parts:

- Feeding bunker;
- Compression chamber;
- Die;
- Pressing rollers;
- Motor.

The **matrix** gives not only the final material of the pellet, but also the resistance force on the raw material and has a direct influence on the transfer rate and on the quality of pellets. These two forces (rollers and the matrix) are in opposition one from another, but need to work together in order to offer quality pellets at an acceptable production rate. The force generated by the roller must be bigger than the resistance force given by the die because if not, the yield will be zero.

Rollers (fig. 2) can have cylindrical or cone shape. The surfaces of rollers are corrugated or can hade various imprint shapes. During movement, rollers press the material inside din orifices of the die, each die channel being active only as long as it is situated in front of a pressing roller.

The main purpose of the roller is to apply a force on the mass in order to compress the material and make it slide through the die. The distance between the roller and the die, the characteristics of the roller surface and the physical properties of the mass determine how big this potential force would be.

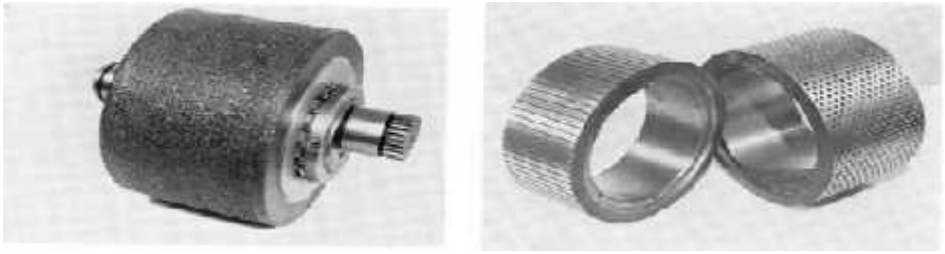

Fig. 2. – *Example of pressing rollers* [15]
a – made of tungsten carbide, b – corrugated or indented

The material is pressed through the special die. Due to the high pressure (800-900 bar) and the high pressure that results when pressing the material, lignin, the natural binder contained by woody materials, melts and helps forming the pellets at the sizes and shape identical to the ones of orifices in the die. Good quality pellets can be obtained at an adequate pressure and die temperature thus is recommended to have a continuous long term operation of the pelletizing presses. A phenomenon seldom encountered when the pellets presses stop suddenly is the jamming of material in the orifices of the die. Dies are usually cylindrical with horizontal axle or flat disk type with vertical axle.

After they come out of the pelletizing machine, warm pellets need to be cooled in order to reach a solid state with a sufficiently high strength. Cooled pellets are usually passed through a vibrating sorter, where small particles and dust are separated, and with the help of a transporter are returned to the material bunker. Pellets thus obtained are transferred to the packing equipment, where they are loaded in bags. The capacity of pelletizing presses is usually between 500 kg/h and 30000 kg kg/h.

In order to produce high quality pellets, the following conditions have to be fulfilled:

- Adequate purity for the raw material (without any foreign matter);
- Raw material with adequate moisture (from 10 up to 20%, depending on the type of material);
- Optimal pellet length;
- Power and temperature adjusted adequately, depending on the type of material;
- Cooling pellets after pressing;
- Sorting pellets before packing.

If these criteria are fulfilled, the final product obtained will have a smooth, glossy surface without any longitudinal cracks, adequate density and shape (fig. 3).

Fig. 3 – *Example of pellets*

The most common equipment used in pelletizing are those with one die and one or more pressure rollers. They are available in two constructive versions:

- with flat die
- with ring die.

Flat die pelletizing machine

The flat die pelletizing machines was the first pellet press designed at the beginning of the 20th century, being based on flat dies. Generally, there are two types on flat dies on the market, the rotating die with stationary rollers and the stationary die with rotary rollers. By adopting the vertical principle, the raw material falls under its own weight in the pelletizing chamber where is compressed between the rollers and the die forming pellets by passing through the orifices of the die.

Overall, flat die pelletizing machines are generally used for processing materials with high adhesion forces, to produce pellets to be used both as fuel as well as for animal food, at low and medium scale. These machines are known due to their characteristics such as safe operation, high mobility, low noise, low energy consumption, but also low productivity compared to the ring die machine.

Fig. 4 – Operating principle of flat die pelletizing machines [5]

Figures 5 and 6 show examples of flat die pelletizing machines,which can be used by the majority of low scale producers.

Fig. 5– Flat die reduced scale pelletizing machine– KMEC [11]

The machine is suited for processing a multitude of biomass materials, with particle dimensions up to 6 mm and moisture between 5-30%. The machine is equipped with a device for compensating the changes that occur in the material, so that there are no agglomerations or jams.

Fig. 6 – Low capacity pelletizing machine–Mechanika Nawrocki, Poland [13]

The machine is suited for producing pellets from bulk materials and biomass (dry and pulverized). The machine is recommended for producers that do not need industrial quantities or for those who process a large variety of materials. It is equipped with conical feeder, magnetic separator, speed regulator for proportioning the material, pelletizing press with command panel, 18.5 kW engine with transmission, 1 die, 2 complete pressing rollers, toolkit, power cable.

It operates well using any type of agricultural or forestry biomass with a granulation depending on the orifices of the die used and optimal moisture of 14-16%. It has a capacity of 150-200 kg/h for superior quality pellets and 200-300 kg/h for industrial pellets.

The capacity depends on:

- The formula (composition, material type);
- Diameter and length of the orifices in the die;
- Operating manner.

Advantages and disadvantages of the flat die pelletizing machine:

- Flat die pelletizing machines have reduced sized and weight due to their compact structure;
- They are easy to clean and maintain and are also cheaper due to the design of rollers and of the die;
- They are easy to transport and move making it possible to for them to be used by a multitude of producers in production various conditions;
- They have low energy consumption.
- It is easier to monitor the pelletizing process in flat die machines by looking through the visitation room;
- The *disadvantages* of this type of machines consist in the fact that they are not fit for large scale production. Also, it is complicated to adjust the distance between the pressing roller and the matrix depending on the properties of the raw material.

Ring die pelletizing machines

Ring die pelletizing machines were designed after the flat die machines, on the basis of the ring die. The base pelletizing principle of the ring die machine is a simple operation where the material is distributed on the interior surface of a perforated rotating die in the vicinity of each pressing roller, which compresses the material mass and forces it to pass through the orifices of the die, thus forming pellets.

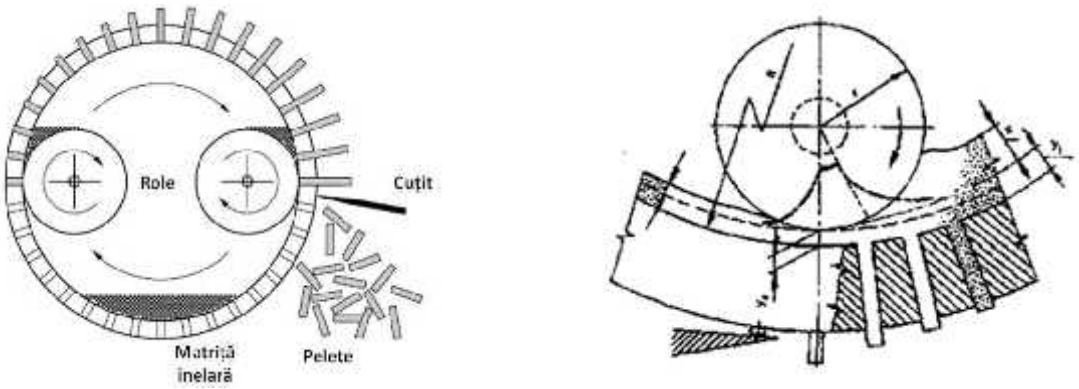

Fig. 7 – Operating principle of the ring die pelletizing machine [6]

Pellets are actually formed at the contact line between rollers and the die. All other activities connected to this operation, such as conditioning, cooling, etc., supports and enhance the action in that moment in the system. In order to understand the process and to improve transit, quality or aspect, one must have a very good understanding on what happens in the catch point between the rollers and the die.

The “extrusion area” is the point where the mass has reached the density of pellets and begins to slide through the orifices of the machine. There are many physical forces that need to be studied and treated in the pelletizing process.

MABRIK pelletizing presses (fig. 8) are built or extremely robust and high quality materials. They are very reliable in extreme conditions and can be used to produce pellets from alfalfa, secondary product from agriculture, waste, wood, etc.

Material inlet and the pressing chamber are made of high resistance stainless steel. The visitation door has a sensor for delaying opening, until the moment when the rollers are had completely stopped. All models can be equipped with dies having different widths, depending on necessities.

Fig. 8– Ring die pelletizing machine–MABRIK company [12]

CMP systems are known for their easy functionality and very long life duration. Energy transfer is very efficient in these systems. Their robust and reliable construction makes the equipment extremely valuable in large size applications for pellet production. CMP systems are available in a large variety of die sizes and powers in order to answer requirements from users.

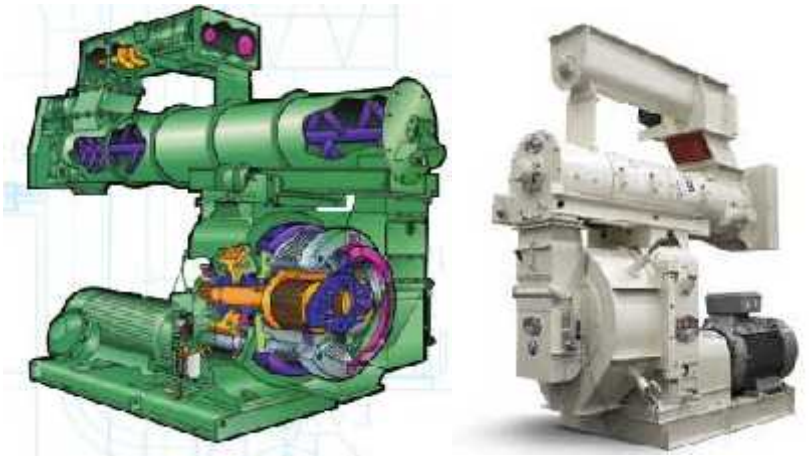

Fig. 9–Ring die compact pelletizing equipment–CMPCompany [14]

Advantages and disadvantages of ring die pelletizing machines:

- Ring die pelletizing machines generate less wear and tear because the interior and exterior edges of the pressing rollers traverse the same distance;
- They more energy efficient than flat die pelletizing machines;
- One of the *problems* of ring die pelletizing machines is side sliding. Side sliding is one of the indisputable and inevitable factors of this type of machine. It refers to the extrusion of material lateral to the point of compression between the roller and the die, a problem that can be minimized depending on the configuration of the die;
- They are very large in size and can only be used by large scale producers.
- Maintenance is more difficult compare and pressing rollers and dies are very expensive compared to the flat die machines.

CONCLUSIONS

Densification is a promising option for obtaining solid biofuels from biomass. During densification, biomass is mechanically compressed, causing density increase by approximately ten times. Commercially, biomass densification is achieved using specially designed pelleting machines.

Flat die pelletizing machines are used for low and medium scale production of pellets. They have high mobility and low energy consumption.

Ring die pelletizing machines can be used for large scale production. They operate smoothly, forming superior quality pellets, with high densities and have high energy consumption.

ACKNOLEDGEMENT

The work has been funded by Ministry of National Education and Research through the Executive Agency for Higher Education, Research, Development and Innovation Funding, within the project entitled „Optimizing the composition of biomass mixtures for obtaining high quality pellets"", BG 24 / 2016.

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