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MECHANICAL TESTING EQUIPMENT FOR PELLETS AND BRIQUETTES

Gheorghe ȘOVĂIALĂ[1], Gabriela MATACHE[1], Alina Iolanda POPESCU[1], Carmen NECULA[1]

[1] Hydraulics and Pneumatics Research Institute INOE 2000-IHP, sovaiala.ihp@fluidas.ro

Abstract: *The article analyzes and presents a methodology and equipment for mechanical testing of briquettes and pellets from biomass in general and from sawdust in particular. Most of the time the buyers of briquettes or pellets face the situation in which the transport does not take place on flat roads and as a result there is a destruction of the pellets or briquettes due to the mechanical shocks that appear. In order to eliminate these problems, the technology and the production equipment must ensure a physical stability of the product, which is why at the approval and periodically, mechanical tests must be carried out in accordance with ISO 17831 defining both the technology and the materials introduced. The article presents a solution of equipment made by the authors, which can be used by researchers and manufacturers and users of briquettes and pellets to verify the durability of these types of products.*

Keywords*: Pelletizing, mechanical testing equipment, mechanical durability*

1. Introduction

In the last few decades, the use of biomass instead of fossil fuels has transformed from an interesting and possible solution into a necessity and more recently into an obligation of the countries, at European and global level. Biomass whether agricultural or forestry tends to be used more and more in the form of briquettes or pellets. It seems that both the manufacturing technology and the quality of the raw material and the final product are well established by international standards and norms. Since renewable energies are generally more expensive than conventional ones, the great advantages of the energy obtained from biomass must be emphasized. Only if we refer to the CO_2 balance and to the fact that the raw material is composed of vegetal residues, including forestry, and plants that produce energy of high yield, we realize the utility in perspective of this type of energy. The most interesting solution for the processing of biomass for its use in energy is its transformation into briquettes and pellets. The big differences between the two products are related to size, density and ash content, but also the possibilities of including them in automatic combustion equipment. The compaction methods have as a common element the pressing operation, through which the thickening of the particles of the primary material is produced, resulting in the increase of the density of the finished product (tablets, pellets, briquettes, etc.).

The pellets are produced by chopping sawdust, wood chips, splints, tree shells, fodder, etc. and pressing of the material obtained through a mould. The heat resulting from friction is sufficient for softening the lignin. By cooling, the lignin becomes rigid and binds the material. The pellets have a cylindrical or spherical shape with a diameter of less than 25 mm (usually 6 ... 8 mm). The briquettes are rectangular or cylindrical in shape and are obtained by pressing together the sawdust, chips, splints or tree shells in a piston or screw press. The energy content of pellets and briquettes is about 17 GJ / ton, with a moisture content of 10% and a density of about 600-700 kg / m3.

The main advantages of wood biomass densification are:

- Increased density of compressed material (from 80-150 kg / m^3 for straw or 200 kg / m^3 for wood sawdust up to 600-700 kg / m^3 for final products);
- Higher caloric power and a homogeneous structure of compressed products;
- A low moisture content (less than 10%).

The raw material used for the production of pellets and briquettes must meet certain physical characteristics, important during the densification process:

• Material fluidity and adhesive capacities (different additives, such as lubricants or binders, may be used to provide the respective characteristics);

Fig. 1. a- Pellets b- Briquettes

- Predetermined dimensions of the particles of the raw material (too thin a choppers can increase the cohesion properties, causing a reduced flow of the material);
- Material hardness (too much hardness of the particles creates difficulties during the densification process) [1].

2. Description of the biomass pelletizing process

The process of producing pellets involves subjecting the biomass to high pressures and forcing it to pass through the cylindrical holes of a mould. When exposed to appropriate conditions, the biomass "fuses" into a solid mass. This process is called extrusion.
The pellets are manufactured by pressing without binders the wood waste or from the secondary agricultural production (straw, sunflower strains, soybean and rape, stalk and corn cobs, cereal residues, ropes of vine, branches resulting from maintenance work from orchards, leaves, seeds and peels of seeds from the food industry).
The material subjected to the pelletizing process must meet two essential conditions: the size of the pellets between 30-50 mm and the maximum humidity 15%. In this regard, a pellet manufacturing line will include equipment for drying the raw material, chopping and pelletizing.

2.1 Equipment for biomass pelletizing

The most important equipment for pelletizing biomass are presses, with active moulding organs and pressing rollers. There are several constructive variants of the pelletizing equipment, in fig. 2 a, b, are presented those: with annular mould and press rolls, respectively with flat mould and press rolls. For each of the mentioned variants, the pressing moulds / rollers can be rotary or fixed [2].
The usual system for making pellets is the extrusion of the chopped material through a mould provided with a series of holes.
In general, pellet presses are the main equipment in a pellet production line. The technical characteristics of a pellet press greatly influence the quality and productivity. These characteristics are generally the size of the mould, the speed of the mould and the distance between the working elements. The material, with the help of rollers, is pressed through the mould, thus forming the pellets. On the outside of the mould a knife cuts the pellets to the desired length. After extrusion the pellets reach the temperature of 90-100°C and are transported to the refrigerator, where their temperature drops to 25°C. It fixes lignin and strengthens the product, helping to maintain its quality in storage and transport. Finally, they are sieved so that the residual debris is separated and reused in the process. Dust-free pellets are ready for storage, transported to packing equipment and stored.

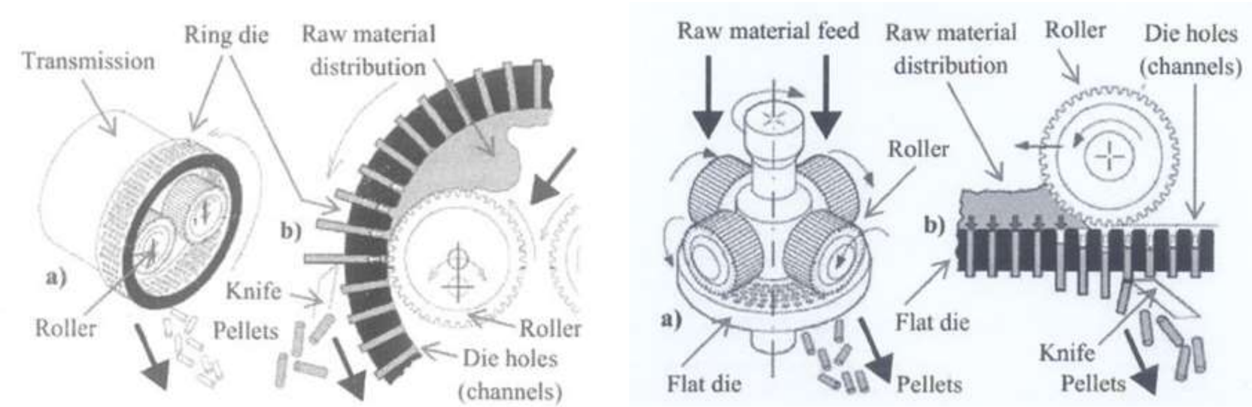

Fig. 2. a Pelletizing chamber with rotating annular mould and fixed press rollers [3]

b. Pelletizing chamber with fixed flat mould and rotary press rollers [3]

A pelletizing equipment, fig. 2 is composed of:
- helical feed system with dosing role of the compaction material;
- funnel for directing the compaction material;
- pellet press;
- drive gear motor;
- control cabinet.

The most common devices used for pelletizing are those with mould and one or more pressing rollers. These are available in two constructive variants:
- with fixed mould and movable rollers
- with rotary mould and fixed rollers (with rotation movement only around its own axis).

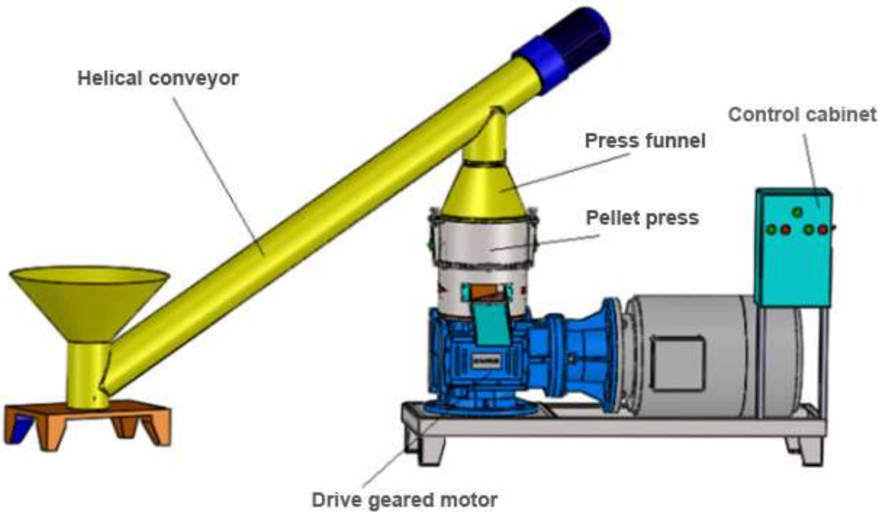

Fig. 3. Pellet press with feed and dosing with helical conveyor

2.2. Determination of the technical-functional parameters of pelletizing presses

On the stands destined for the experimentation of the active parts of the pelletizing presses made worldwide, for each type of biomass 4 parameters are monitored:
- the force required to extrude the biomass in the mould with a single hole, respectively with multiple holes;

- static and dynamic friction forces generated at the contact between the active piece of the press (die or press roller, depending on the constructive variant) with the material of high density and small thickness formed between them in the extrusion process;
- the compressive strength of the pellets obtained;
- pellet density.

In fig. 4 is presented the multifunctional test stand made at Danish Technological Institute in Denmark, with which it is followed the variation of the parameters of compressive strength and extruded material density along the extrusion hole (diagram in fig. 5), respectively the mechanical resistance of the pellets under the action of a compressive force, fig.6, fig. 7. [4]

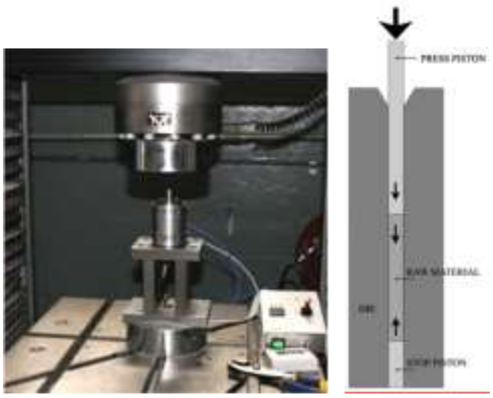

Fig. 4. Stand for determining the extrusion force (single hole mould) [4]

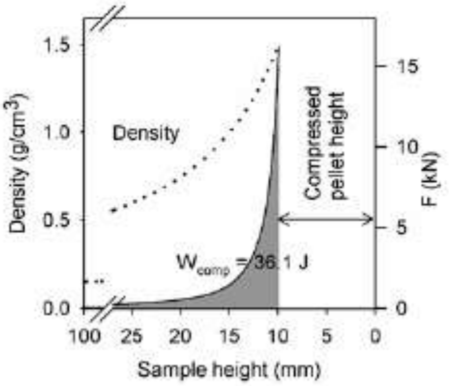

Fig. 5. Variation of the compressive strength and density of the pellets along the extrusion hole [4]

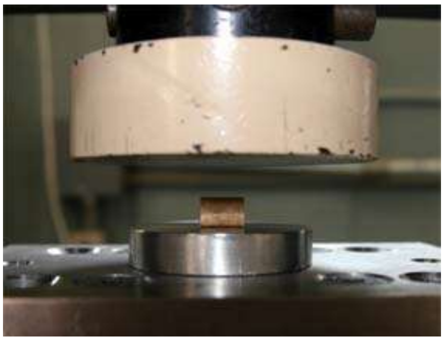

Fig. 6. Stand for determining the mechanical strength of the pellets when applying a compressive force [4]

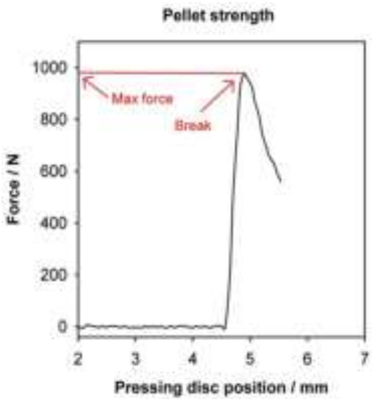

Fig. 7. Determining the quality of the pellets by compression [4]

The density of the pellets is determined by measurements (length, diameter and weight) and application of the known calculation formula [2].

3. Testing of briquettes and pellets

The testing of briquettes and / or pellets is done in the introduction phase, in the manufacturing reception phase and in the use phase of the products. It is possible that some tests and verifications may be carried out in one or more phases, the verification method and equipment being the same or different.

A stand was created to determine the extrusion force of pellets. Considering the above considerations, it was considered necessary to perform it in order to perform the extrusion force determinations for several types of biomass.
The overall drawing of the device for determining the pellet extrusion forces is shown in Fig. 8.

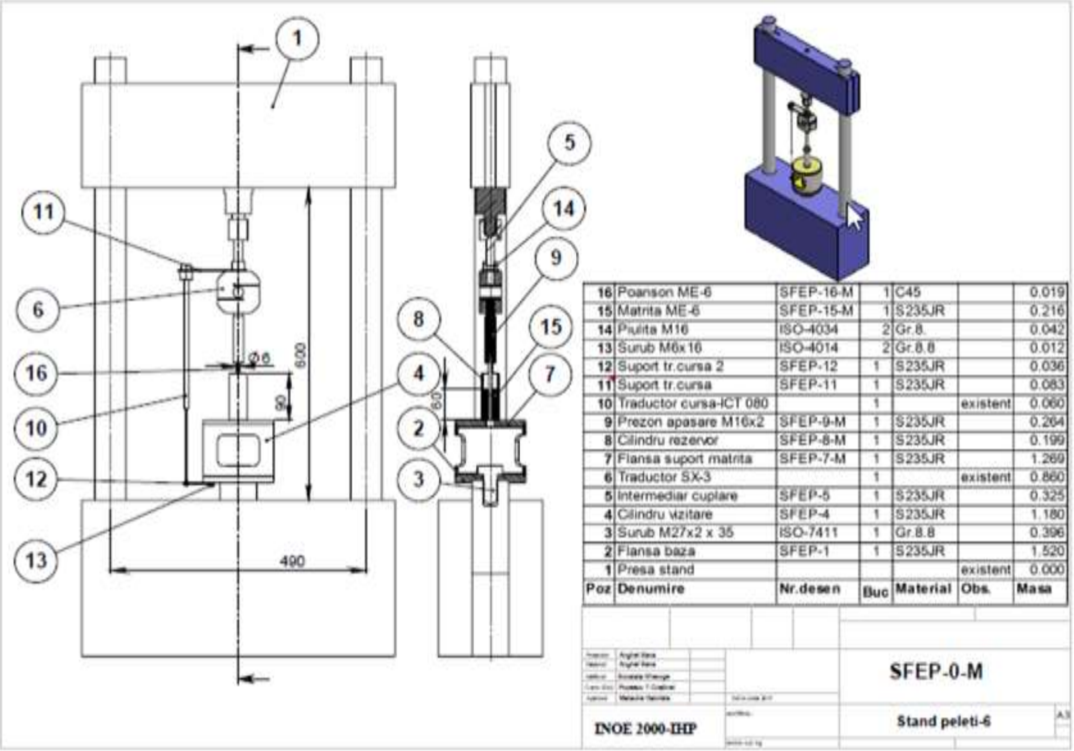

Fig. 8. Overall drawing of the device for determining pellet extrusion forces

The stand made by IHP, fig. 9, fig. 10, is composed of a rigid resistance frame, integral with the linear of the hydraulic drive cylinder 5, a cross that can be moved on two columns and fixed in the desired working position, a pressing device 3, in solidarity with the rod of the hydraulic cylinder. The force transducer 1 and the piston for pressing the extruded material into the mould are mounted on the cross member.
The hole in the mould and the pressing piston are perfectly coaxial, so as to avoid the occurrence of moments generated by the eventual release.
The pressing of the material is done by moving the pressing device vertically towards the pressing piston.
Between the pressing device (mobile) and the cross member, which by fixing with screws on columns, closes in the upper part of the test enclosure 4, a resistive displacement transducer 2 is mounted.
The hydraulic power supply of the drive cylinder is made from a hydraulic unit, consisting of an oil tank, electric pump 12, return filter 11, safety valve 10. The pressure gauge 9, mounted on the discharge circuit of the pumping group indicates the pressure value hydraulic oil when entering the working fluid distribution apparatus. Servovalve 8 allows very precise control of the value of the flow / pressure working parameters for the execution element (hydraulic cylinder), by the size of the electrical control signal; by their values, the flow rates and pressures regulated by the servo valve determine the values of the speeds and forces of the cylinder rod, imposed by the experiments performed on the stand.
The pressure transducer 6, mounted on the feed circuit of the piston chamber of the hydraulic cylinder, provides information on the pressure value during the biomass compression process. Hydro-pneumatic accumulators 7, have the role of attenuating the pulsations and maintaining at

constant value the pressure in the rod / piston chambers of the hydraulic cylinder during the working sequences compressing extruded material in the mould / piston retraction. The compressive strength of the biomass in the extrusion process is determined on a single hole mould with a diameter of 6 mm and a depth of 60 mm.
The data that are the subject of the experiments are acquired with the help of a data acquisition system.
Fig. 10 shows the block diagram of the stand for determining the extrusion force of pellets.

Fig. 9. Physical realization of the research stand

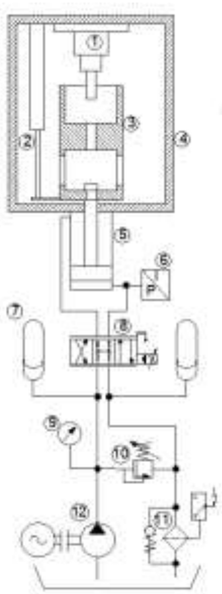

Fig. 10. Pellet stand hydraulic diagram1-strong translator; 2-position translator; 3-pressing device; 4-metal frame; 5-hydraulic cylinder; 6-pressure transducer; 7-hydropneumatic battery; 8 servovalve; 9-gauge; 10-safety valve; 11-return filter; 12 electropump

4. Conclusions

Research on the integration of mechatronic components and systems in biomass compaction equipment for the purpose of extending compaction applications to various types of biomass from agricultural or forestry is of great interest for pellet and briquette producers. Within the INOE 2000-IHP institute, the researches in this direction aim to establish the parameters (mainly the compaction pressure, temperature, humidity of the material, working speed, shape and dimensions of the final product depending on the material, etc.). Providing sensors and transducers for these sizes will allow a machine to expand its range of use, by adapting the working parameters to the material to be compacted. The adjustment of the working pressure and the feed rate of the material in the area of the briquette / pellet formation will be done by the variation of the hydraulic pressure and flow parameters, in the case of the machines with main hydraulic drive.

Acknowledgments

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♦ ISO 17828: Solid biofuels - Determination of bulk density.
♦ ISO 17829: Solid Biofuels - Determination of length and diameter of pellets.
♦ ISO 17831-1: Solid biofuels - Determination of mechanical durability of pellets and briquettes - Part 1: Pellets.
♦ ISO 18122: Solid biofuels - Determination of ash content.
♦ ISO 18125: Solid biofuels - Determination of calorific value.
♦ ISO 18134: Solid biofuels - Determination of moisture content.
♦ ISO 18846: Solid biofuels - Determination of fines content in quantities of pellets.
♦ ISO 9001: Quality Management Systems – Requirements.