Influence of the particle size distribution and water content on the pelletizing energy consumption

Bruno Godin[1,*], Romain Marchal[1], Andreas Arimont[1], Michaël Temmerman[1], Jérôme Delcarte[1]

[1] Walloon Agricultural Research Center – CRA-W. Valorisation of Agricultural Products Department.

Biomass, Bioproducts and Energy Unit. Chaussée de Namur, 146. B-5030 Gembloux, Belgium

Corresponding email : b.godin@cra.wallonie.be

Introduction

● Biomasses have variable:
- Water content
- Bulk density
- Non-homogeneous particle size distribution

● The energy consumed for pelletizing the material depends on:
- Raw material properties like the type of biomass, water content and particle size distribution;
- Process parameters like the distance between rollers and die, and the die temperature and geometry (ratio die hole length to diameter).

● Pelletizing energy is the sum of the energy required for (Figure 1):
- The compression of the material;
- To force the material to flow into the die holes;
- To push the material out of the hole. The latter is dominated by frictional forces.

● The pelletizing pressure cannot be measured in the channels of a rotating die
→ The pelletizing process is simulated in a single pelletizer unit (SPU).

● The aim of this study is to measure the influence of the particle size distribution (PSD) and biomass water content on the pelletizing energy in a single pelletizer unit (SPU).

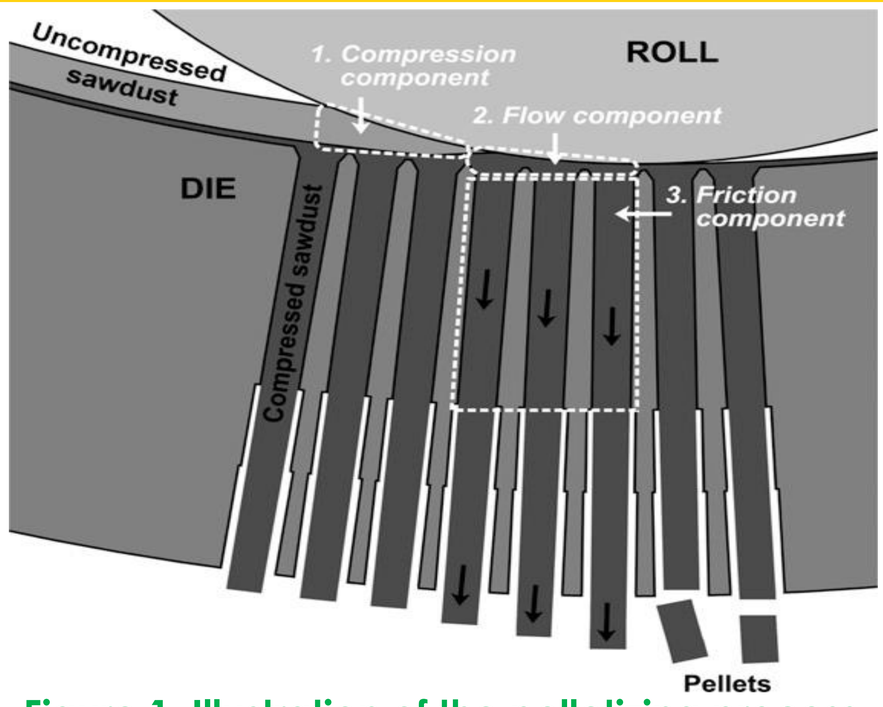


Figure 1. Illustration of the pelletizing process.

Tool to assess and compare the pelletizing energy consumption

Assessed raw materials

● 4 types of biomass (spruce, bamboo, fescue and sorghum) ground and moistened to different particle size distribution (PSD) and biomass water content classes:
- 8 mm (PSD8), 5 mm (PSD5), 3 mm (PSD3) and 2 mm (PSD2);
- 24% (H24), 20% (H20), 17% (H17), 15% (H15) and 12% (H12).

Single pelletizer unit (SPU)

● The total pelletizing energy is calculated as the sum of the individual force values multiplied by the displacement. This pelletizing energy is divided by pellet weight in order to have the specific pelletizing energy in kWh/t:

$$W_{spec} = \frac{\sum_{i=1}^{n} F_i \cdot \Delta x}{m}$$

- W_{spec} is the specific palletizing energy consumption;
- n is the number of measurements taken;
- Δx is the displacement per measurement;
- m is the mass of the produced pellet.

For each assay, 12 pellets were produced.

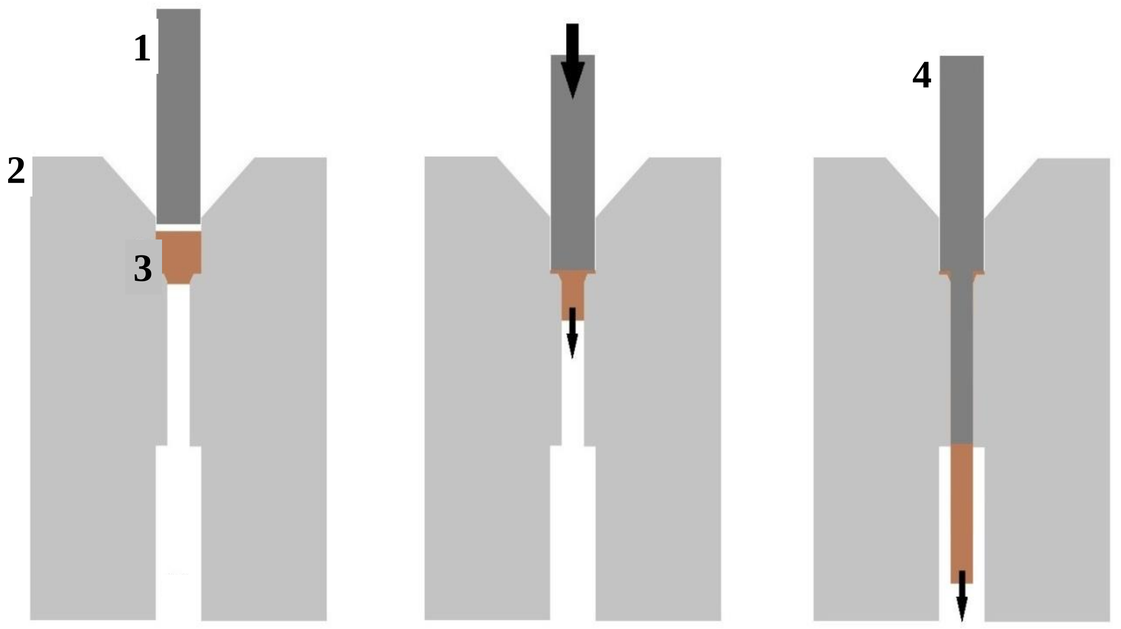
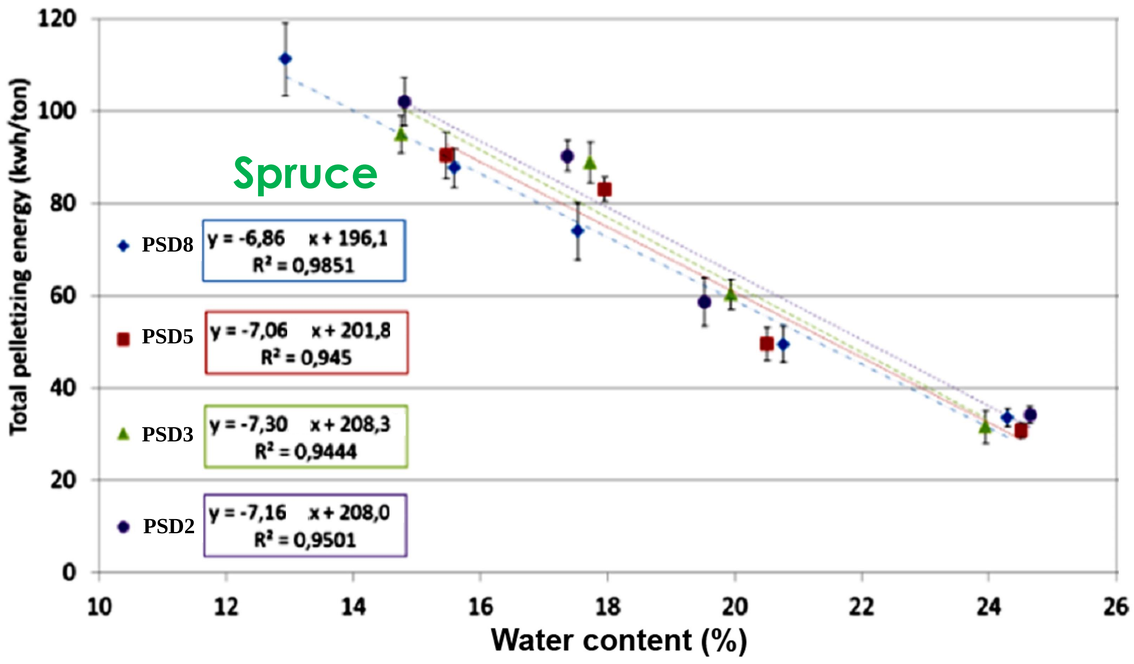
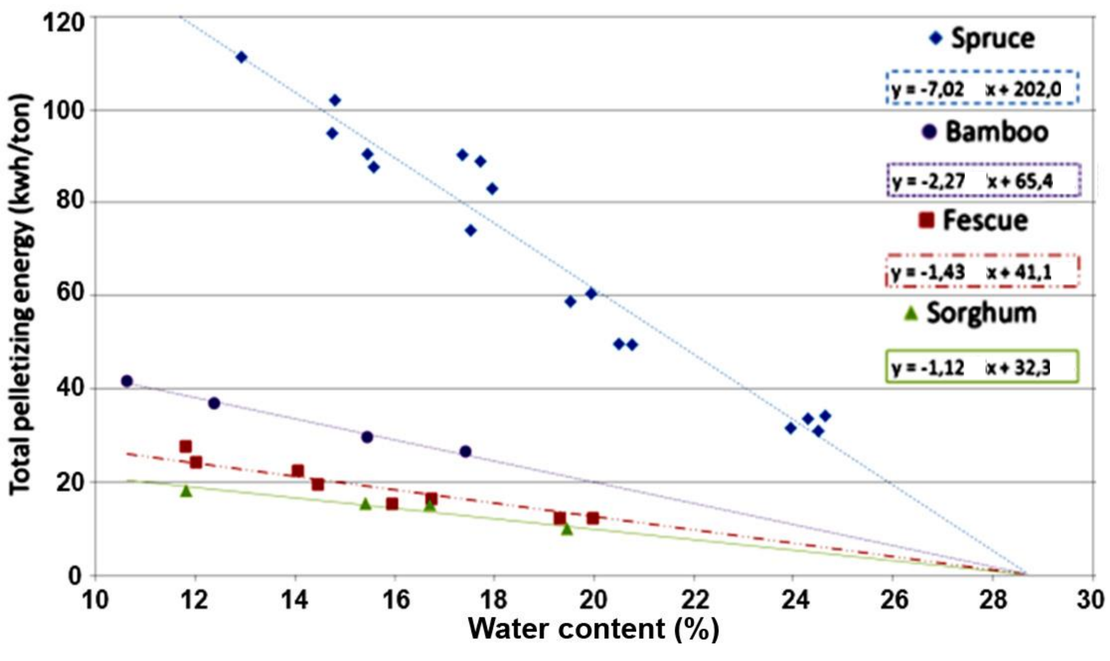


Figure 2. Single pelletizer unit (SPU).
1: Compression piston; 2 : Die; 3: Biomass; 4: Extraction piston.

Pelletizing energy consumption





● Pelletizing energy consumption
- Significant impact of the biomass water content. The specific pelletizing energy consumption increases with the decrease of the water content.
- No significant impact of the particle size distribution (PSD).

● Linear relationship between specific pelletizing energy and biomass water content.
- For a water content of 28.7%, the specific pelletizing energy consumption is nil for all the tested biomasses.

$E_p = C_m \times (28{,}7 - H)$ E_p is the specific pelletizing energy consumption, C_m a constant depending on the type of biomass and H is the water content.

● The value for the C_m coefficient is of 1,13 for sorghum, 1,43 for fescue, 2,28 for bamboo and 7,03 for spruce.
- Those C_m values mean that, for the same water content, bamboo and spruce need, respectively, 2 and 7 times more energy to be pelleted compared to sorghum and fescue. This could be explained by the chemical composition (like the lignin content) of the biomass.

Conclusions

● For the tested biomasses (spruce, bamboo, fescue and sorghum):
→ Spruce has the highest energy consumption level followed by bamboo, fescue and sorghum;
→ Significant linear relationship between total pelletizing energy and biomass water content;
→ Particle size distribution (PSD) has no significant impact on the pelletizing energy.

Wallonie

Walloon Agricultural Research Centre