Name: Date: Class/Hour:

BIOMASS DENSIFICATION AND QUALITY OF DENSIFIED BIOMASS

INTRODUCTION

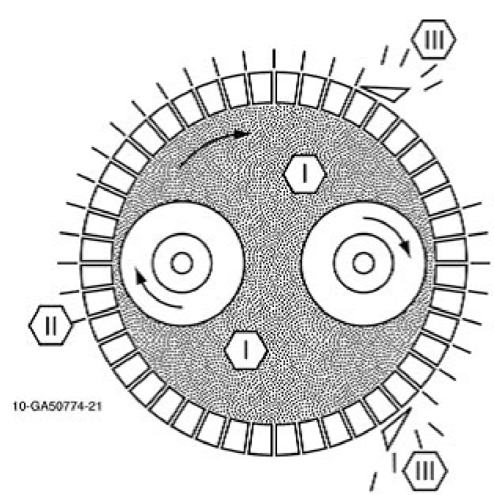
Biomass crops and residues have properties which make it less-than-ideal for handling and storage. Because raw biomass tends to have rather low density, it is not economical to transport or store. Further, since unprocessed biomass such as corn stover or wood waste typically contain different sized particles, it tends to knit together, impairing flow properties and creating wide ranges in bulk density and moisture content. This can lead to other problems like dust generation when handling or self-combustion during storage. Therefore, processes have been developed to increase the density and uniformity of biomass so it can be more economically transported, handled, and incorporated into bioenergy systems. Due to the wide variety of types, shapes, sizes, and end-uses for biomass, methods of densification and the parameters used to evaluate the quality of the material will vary considerably.

This exercise will focus on understanding various processes of biomass densification and investigate methods used to evaluate the quality of densified biomass for use as fuel.

BACKGROUND

Biomass densification has been employed in the agricultural industry for many years. The most common type of biomass densification used in agriculture is baling, which gathers loose plant material such as hay, straw, or corn stover and compresses it into a square or round bale. Baling facilitates short-range transport of raw biomass from a field to storage or processing areas, but the densities obtained through baling are not great enough to facilitate long range transport or maximize storage space. Further, the variation in particle size, moisture, and density of baled biomass make it problematic for incorporation into most bioenergy systems. Therefore, secondary densification systems have been developed to further densify biomass and create a product that is more economic for transport and has the uniformity required for industrial bioenergy systems. The Pellet Fuels Institute has developed a set of standard specifications to be used in evaluating quality of densified biomass to be used as fuel. The procedures described below approximate some of the parameters used to evaluate densified biomass fuels. Two common densification processes are pelletilization and briquetting.

Pelletization is a popular processing technique in feed and fuel manufacturing. In simple terms, pelleting converts finely ground ingredients into dense, free-flowing, durable pellets. A pellet has uniform product characteristics in terms of size (length and diameter: 13–19mm and 6.3–6.4mm), shape (cylindrical), and unit densities (1125–1190kg/m^3). A pelletizer consists of a perforated hard steel die with one or two rollers. By rotating the die and rollers, the feedstock is forced through the perforations to form densified pellets.



I Unpelleted Material
II Pellets Extruded through Die Plate
III Pellet Knives

Briquetting is usually performed using hydraulic, mechanical, or roller presses. Because the densified material has a larger size, briquetting machines typically can handle larger-sized particles and wider moisture contents without the addition of binders compared to pellets.

PROCEDURE

NOTES

PART 1: BULK DENSITY

Materials Needed:

- Densified Biomass
- 1L Plastic Beaker
- Ruler or Straight-edge
- Laboratory Scale capable of weighing the container and sample to within 0.01g

1. Weigh and record the empty container to within 0.01g.

2. Determine the precise volume of the container by filling it to capacity with water and recording the mass of water in the container. Assume the density of water is 1g/cm^3.

3. Pour densified biomass into the dry, empty container to capacity.

4. Drop the container several times from a height of 2-3in. onto a hard surface to allow settling.

5. Add additional sample and strike off the excess so it is level with the top edge of the container.

6. Weigh the box and sample to within 0.01g.

7. Calculate bulk density in g/cm^3 using the below equation, and convert to lbs/ft^3.

Bulk Density (g/cm^3) =

$$\boxed{\frac{(\text{weight of container + sample, g}) - (\text{weight of container, g})}{(\text{volume of container, cm}^3)}}$$

1 g/cm^3 = 62.428 lbs/ft^3

NOTES

PART 2: MOISTURE CONTENT

Materials Needed:
- Densified Biomass
- Drying oven capable of temperature regulation of 103 ± 1°C
- Open, nonporous glass, metal, or ceramic containers capable of holding at least 50cm^3
- Laboratory Scale capable of weighing the container and sample to within 0.01g
- Dessicator of sufficient size to hold sample containers

1. Place empty containers in 103 ± 1°C oven for 30 minutes, then cool in dessicator to room temperature. Weigh and record container weight.

2. Place a minimum of 50g of material in container and weigh to the nearest 0.01g. Record as initial weight.

3. Place sample and container in 103 ± 1°C oven for 16h.

4. Remove sample and container from the oven and cool in the dessicator to room temperature. Remove sample and container and weigh immediately to the nearest 0.01g. Record the last recorded weight as the final weight.

5. Calculate % Moisture as follows:

% Moisture =

$$\left[\frac{\text{(initial weight - final weight)}}{\text{(initial weight - container weight)}}\right] \times 100$$

PROCEDURE

NOTES

PART 3: PERCENT FINES

Materials Needed:

- 1/8-in opening or U.S. Standard No. 6 Wire Screen Sieve
- Receiving Pan
- Laboratory Scale capable of weighing the container and sample to within 0.01g

1. Obtain at least 2.5lbs (1134g) of densified biomass and weigh the sample in a tared container to the nearest 0.01g. Record the sample weight.

2. Weigh the receiving pan to the nearest 0.01g and record the weight of the empty pan.

3. Attach the pan to the sieve and place the sample on the sieve. Important: The amount placed in the sieve should not exceed 1lb (453g) of pellets per 100in^2 (645cm^2). For a typical 8" diameter laboratory sieve the amount placed on the sieve should not exceed 0.5lb (227g). Most laboratory sieves will require that samples of 2.5lbs or more are sieved in increments.

4. Sieve the sample (or portion of sample) by tilting the sieve side to side 10 times.

5. If the sample is being sieved in increments, after the first portion has been sieved, remove the sieve from the pan and remove the pellets from the screen.

6. Repeat steps 3-5 until the entire sample has been sieved.

7. Remove the sieve from the receiving pan and weigh the pan and fines to the nearest 0.01g. Record the weight of the pan and fines.

8. Calculate the percent fines as follows:

% Fines =

$$\left[\frac{\text{(weight of pan + fines) - (weight of pan)}}{\text{(sample weight)}}\right] \times 100$$

NOTES

PART 4: DIAMETER AND LENGTH OF PELLETS

Materials Needed:

- Densified Biomass
- Vernier Caliper capable of measuring diameter and length to within 0.001in
- Laboratory scale capable of weighing the container and sample to within 0.01g
- Ruler or Straight-edge

1. Obtain an approximately 2.5lb sample of pellets, weigh the sample and record to the nearest 0.01g.

2. Hand sort to identify pellets over 1.5 inch (38mm) in length. Confirm the sorted pellets exceed 1.5in with the caliper or other measuring device (ruler). Identify the longest pellet and measure its length to the nearest 0.001 inch using the caliper. Report this length as the maximum pellet length. Weigh and record the pellets exceeding 1.5 inches to the nearest 0.01g.

3. Randomly select five pellets out of the sample and measure the diameter of each pellet using the caliper. Report the average and range of diameters to the nearest 0.001in.

4. Calculate the weight percent of pellets exceeding 1.5 inches as follows:

% Exceeding 1.5 inches =

$$\left[\frac{\text{(weight of pellets exceeding 1.5 in)}}{\text{(sample weight)}}\right] \times 100$$

PROCEDURE

NOTES

PART 5: DURABILITY

Materials Needed:

- Densified Biomass
- 1/8-in opening or U.S. Standard No. 6 Wire Screen Sieve
- Receiving Pan
- Laboratory Scale capable of weighing the container and sample to within 0.01g
- Quart sized reclosable poly storage bags (we recommend using the thicker “freezer” storage bags).
- Tape measure capable of measuring a height of 6 ft.

1. Weigh an approximately 100g sample of pre-screened densified biomass into a tared poly storage bag (you may use the screened sample from the percent fines determination). Record the initial sample weight to the nearest 0.01g.

2. Remove excess air from bag and seal.

3. Hold the bag horizontally at a height of 6ft (183cm) above a hard surface (concrete recommended) and drop the bag. Check that bag remains sealed after each drop, and repeat 9 more times for a total of 10 drops.

4. Weigh the empty sieve and record the weight to the nearest 0.01g.

5. Attach the pan to the sieve and place the sample on the sieve.

6. Sieve the sample by tilting the sieve side to side 10 times.

7. Remove the sieve from the pan and weigh the sieve and sample remaining on the sieve to the nearest 0.01g.

8. Calculate percent durable densified pellets as follows:

% Durable =

$$\left[\frac{\text{(weight of sieve + pellets) - (weight of sieve)}}{\text{(initial sample weight)}}\right] \times 100$$