Effect of Particle and Environmental Variables on Flowability of Granular Materials

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Research Question: How do particle size, shape, moisture, aeration and consolidation affect the flowability of various biomass fines?

Abstract

The main objective of this experiment was to determine a relationship between the physical properties of varying biomasses and sizes with their flowability and overall performance. Tests were done on various micron ranges of two different biomasses using varying equipment and machines. These machines were used to ground, sieve, measure and record in order to collect the proper data for this experiment.

Goal

The purpose of this research is to attempt to design a novel set of characterization tools to relate granular material physical properties to their performance in handling and conversion operations[1]-[2].

Background

Granular materials are used in several industries such as pharmaceutical, food, fertilizer, catalyst, and several other processing industries[3]. Usually, there is a difficulty transporting and storing biomass materials because most of them have low densities and high internal moisture levels. This low density causes the decomposition rate to accelerate along with giving the materials high porosity and hydrophilicity, leading to more moisture absorption from the environment [2], [4].

Materials and Methods

In this experiment, two different biomass materials: corn stover and pine residue were ground using a Retsch Mortar Grinder RM 200 and sieved into different micron ranges (<38 µm, 38-63 µm, 63-106 µm, 106-125 µm, 125-150 µm, 150-180 µm, 180-250 µm, 250-300 µm and 300-355 µm) using a W.S. Tyler Ro-Tap E Sieve Shaker [5]-[6]. These samples were then put into a Freeman FT4 Powder Rheometer, which used a rotating blade to measure the flowability of each micron range for the corn stover and pine residue. These machines are displayed in the following figures:

Figure 1: *Picture of Retsch Mortar Grinder RM 200 [5]*

Figure 2: *Picture of W.S. Tyler Ro-Tap E Sieve Shaker [6]*

Figure 3: *Picture of Freeman FT4 Powder Rheometer [7]*

Results

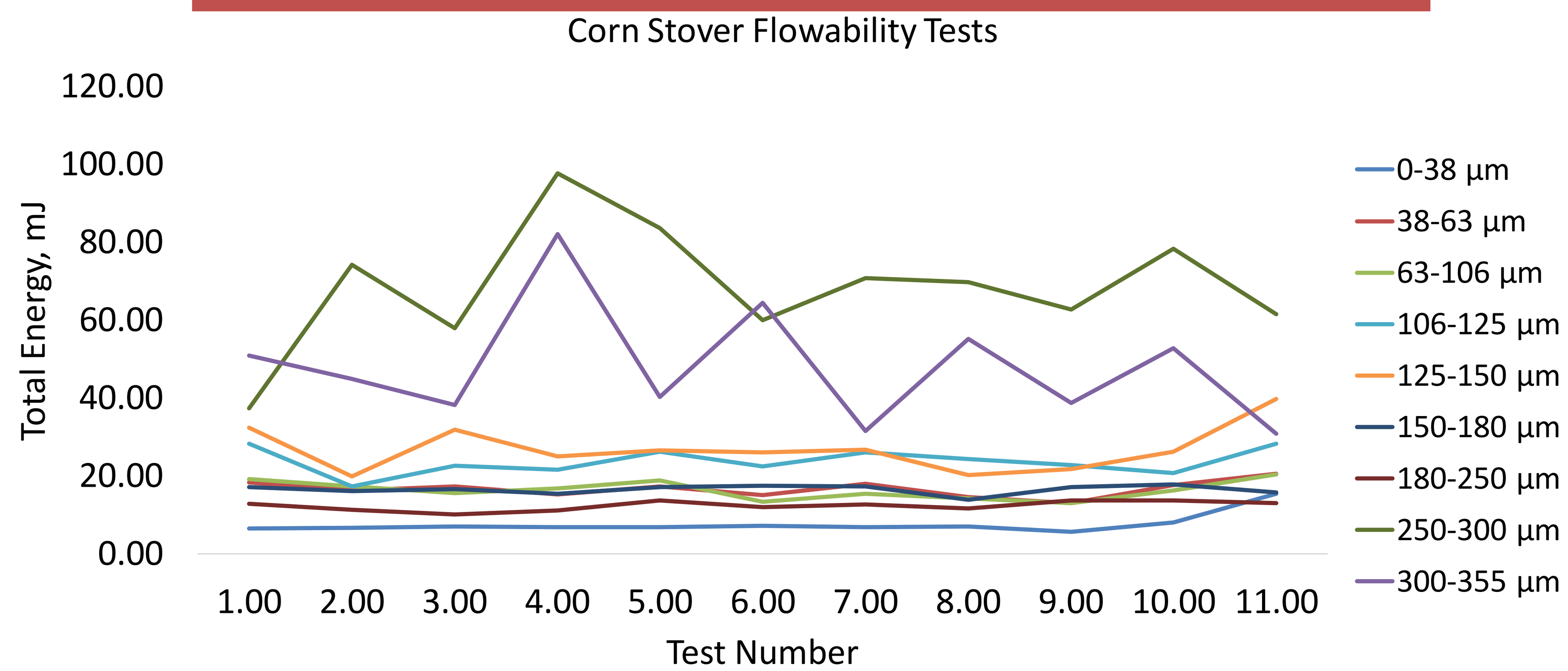

Figure 4: *Total Energy (mJ) for plotted micron ranges of Corn Stover Sample*

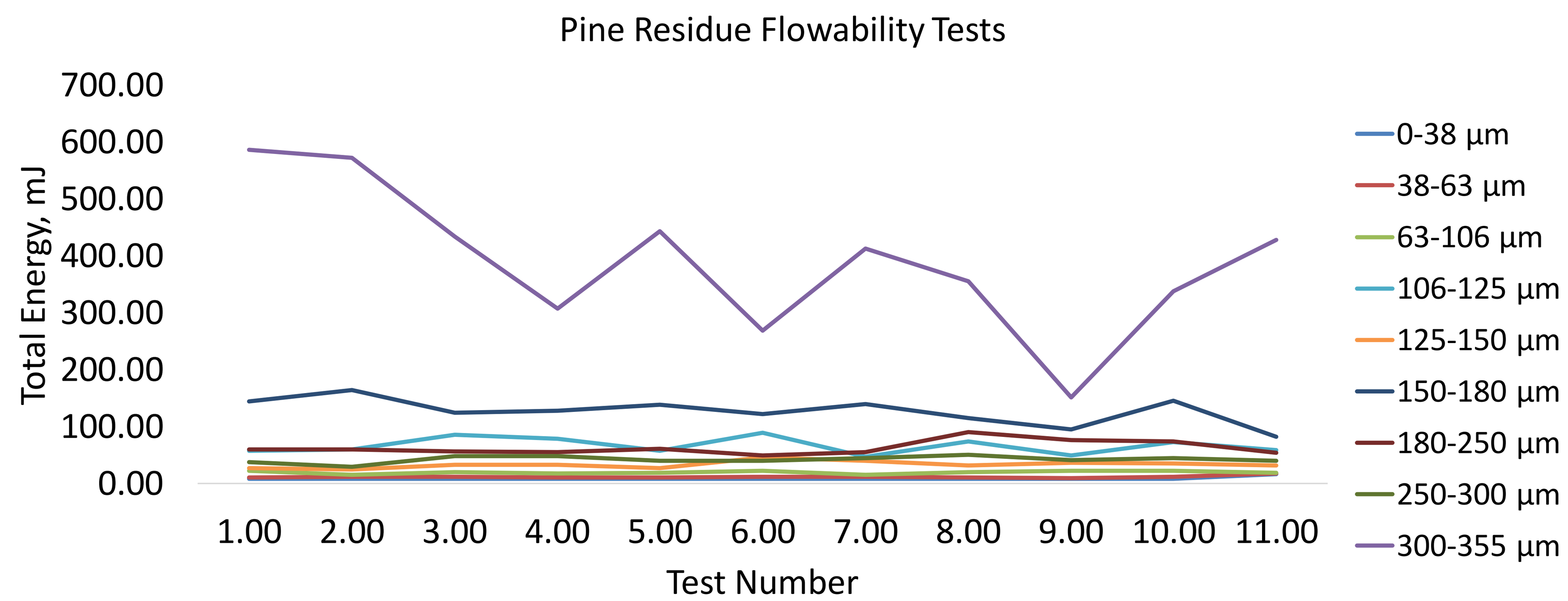

Figure 5: *Total Energy (mJ) for plotted micron ranges of Pine Residue Sample*

Conclusion and Obstacles

Based on the collected data for both samples, as the size of the particles increases, the total amount of energy required in order to flow through it increases as well. This was determined after collecting, plotting, and analyzing the measured data by the FT4 Rheometer, which displayed an increasing trend in total energy (mJ) for the blade to flow through the biomass as the particle size (µm) increased. From this correlation, it can also be determined that as the micron range of the biomass increases, the flowability decreases due to the greater total energy (mJ) required for the blade to flow through it. As for each sample, it appears that the pine residue had slightly higher total energy values than those of the corn stover, causing it to have a lower flowability than the corn stover. This can especially be displayed by the total energy values for the pine residue's 150-180 µm sample, which is nearly eight times those of the corn stover. This difference in flowability values can be attributed to factors such as weight, density and error. Possible sources of error could have arisen from:

- Incorrect measurements
- Unsifted materials in higher micron ranges
- Cross-contamination of samples

Due to the circumstances of COVID-19:

- Alternate materials and size ranges were unable to be tested
- The humidity could not be measured and compared to the flowability
- More analysis of physical and performance properties could not be performed

References

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