Effect of Particle and Environmental Variables on Flowability of Granular Materials

Jason Green, Chemical Engineering
Mentor: Dr. Heather Emady, Assistant Professor
School for Engineering of Matter, Transport and Energy

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 is to determine a relationship between the physical properties of varying biomasses and sizes with their flowability and overall performance. Tests were done on micron ranges of 150-180 μm, 180-250 μm, 250-300 μm and 300-355 μm 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, different biomass materials were ground using a Retsch Mortar Grinder RM 200 and sieved into different micron ranges (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 [7]. These machines are displayed in the following figures:

Results

The collected data, 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. Due to the circumstances of COVID-19, research was halted before further sample sizes, trials and other materials could be run, however, all of these will be conducted and completed during the next semester in order to further explore any correlation of data.

Conclusion and Obstacles

Based on the collected data, 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. Due to the circumstances of COVID-19, research was halted before further sample sizes, trials and other materials could be run, however, all of these will be conducted and completed during the next semester in order to further explore any correlation of data.

Future Plans

• Collect data for more size ranges and more trials from corn stover samples along with all future samples
• Measure flowability for pine residue samples
• Grind up both corn stover and pine residue using alternative grinding methods and measure each flowability
• Compare flowability values for each material based on grinding method

References