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Summary of Project and Results

The title of this research project is “Granular Flow in a Conveyor System” and granular flow actually has applications in many different industries, which it was chosen to continue the development of this research that our faculty advisor has such a vested interest in. Something unique to engineering is that, similar to other hard sciences, it requires extensive analytical, scientific exploration but it goes one step further in most every case, to perform research with regards to a specific application. For example, granular flow can be witnessed in many everyday activities, even in something as simple as pouring cereal in a bowl—certain pieces fall out faster than others, creating an ideal mix of different pieces in the bowl once poured to the desired level. In the case of this research, the application is to contribute to advancements in renewable energy. By tracking mass flow rate in a granular flow conveyor system and looking at velocity profiles while maintaining steady flow in the system, it is hoped to locate the system settings that permit the least amount of energy loss. From there, by utilizing non-dimensional analysis and applying the findings to a real system, steps can be made in the right direction to increase the efficiency of biomass energy extraction systems.

The system is made up of a bottom-driven conveyor belt system that transports a tall layer of particles that fill the space between the two walls that extend upward on either side of the conveyor belt. The particles, of one uniform diameter, are eventually sent through the system and dispensed out an adjustable opening at the right-end of the system (see the two images below). Two independent variables were adjusted in each trial and those were the speed of the belt and the opening height of the exit area. A few instruments were required for the operation of the system and data collection such as a DC motor, a computer, and two sets of bright flood-type

lights, but data was collected using a high-speed camera and a scale to measure two pieces of information in each trial—mass exiting the system and images to help find the positions throughout the entire duration of the trial. Pictures were taken very fast to where the particles in the images could be seen throughout each time step to determine the particle positions from one instance to another. This allowed the tracking of sequential particle positions where then, the particle velocities could be found using several particle positions over a time span. By adjusting the height speed in five levels, with four height sizes, and three sets for each setting, there was a total of 60 trials conducted.

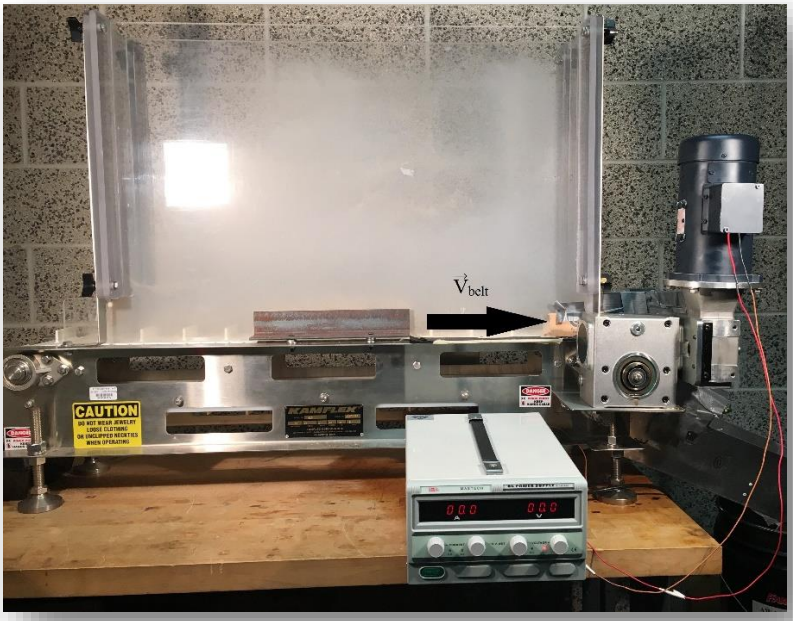

Figure 1: This is the conveyor apparatus used in this experiment. The area labeled V_{belt} is the area where images were captured.

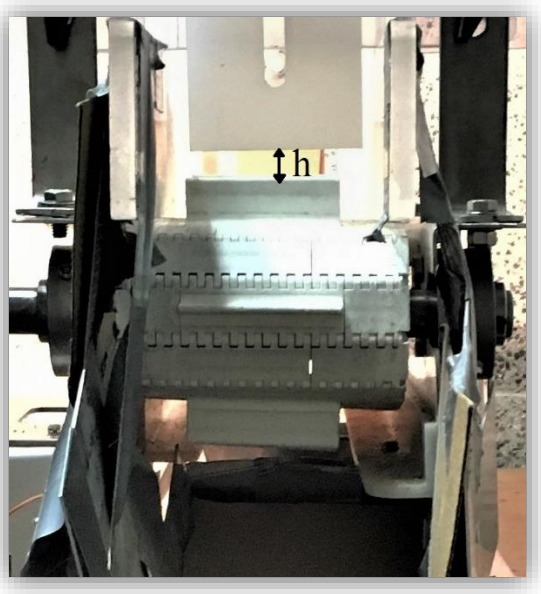

Figure 2: This is the end of the conveyor system where the particles were pushed out into a bucket. The opening heights is shown and labeled 'h'.

Some key results are shown below in the form of two graphs. The first one highlights the different horizontal velocities of particles as the opening height changes. It can be seen that as particles move closer to the bottom belt, their horizontal velocity increases, bringing them up to speed of V_{belt}. Further analysis needs to be conducted to compare the entirety of this data at various opening heights to determine if the degree of decay is greater in this system or previously studied systems to determine whether the conveyor belt system is a step in the right direction for an efficient system. Two other graphs comparing weight vs. time under conditions of varying speed and weight vs. time under conditions of varying opening height were also observed where a greater difference between weight collected was noticed when speed was changed as opposed to opening height. The second topographical-style contour graph below shows the combination of those two independent variables to track the slope, or in this case, the mass flow rate of the particles, to witness a relative peak. It is unsure whether this peak continues or serves to

represent a local maximum. Further trials at this diameter and increasing opening height and speed need to be conducted to determine that.

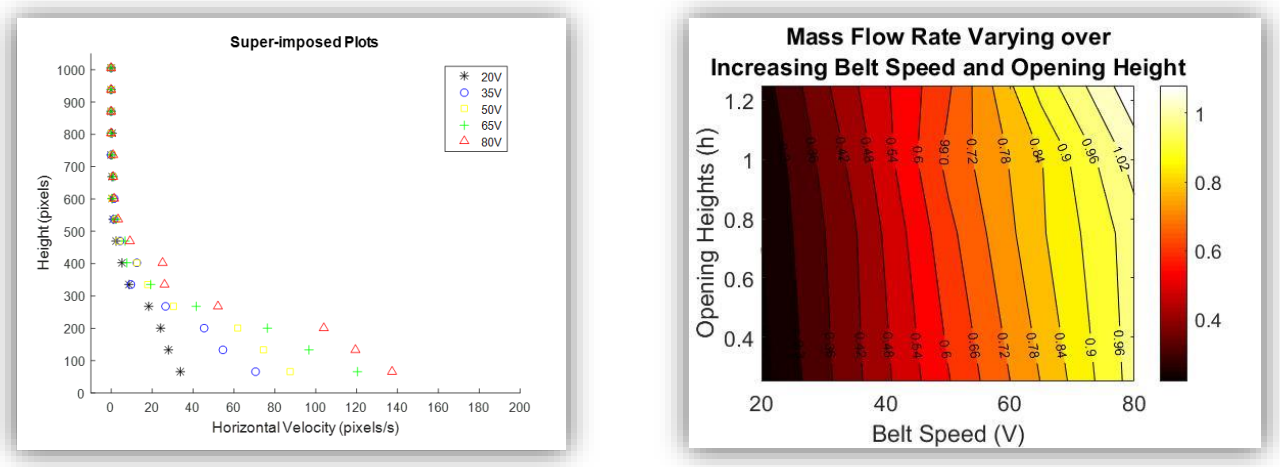

Figure 3: From left--velocity profile for each belt speed in the system; a contour plot that shows how the slope varied for each independent variable.

Accomplishing Original Objectives

The original objectives of this project have indeed been accomplished. We obtained results for the research to leave many doors for future students to explore and conduct analysis on. This includes exploring the peak of the contour plot, gathering the data to create superimposed plots (both shown above), and in the area I began to explore individually in this project, tracking the position of non-uniform particles (as the particles in this system have been uniform thus far). As far as the additional, non-engineering-related results of this project go, this definitely increased exposure of the college of engineering to the university, which is a great achievement. I believe that my presence and guidance as a mentor, sponsored by SEF, helped to guide the freshman Research Rookie into the program with better guidance than if I was not present.

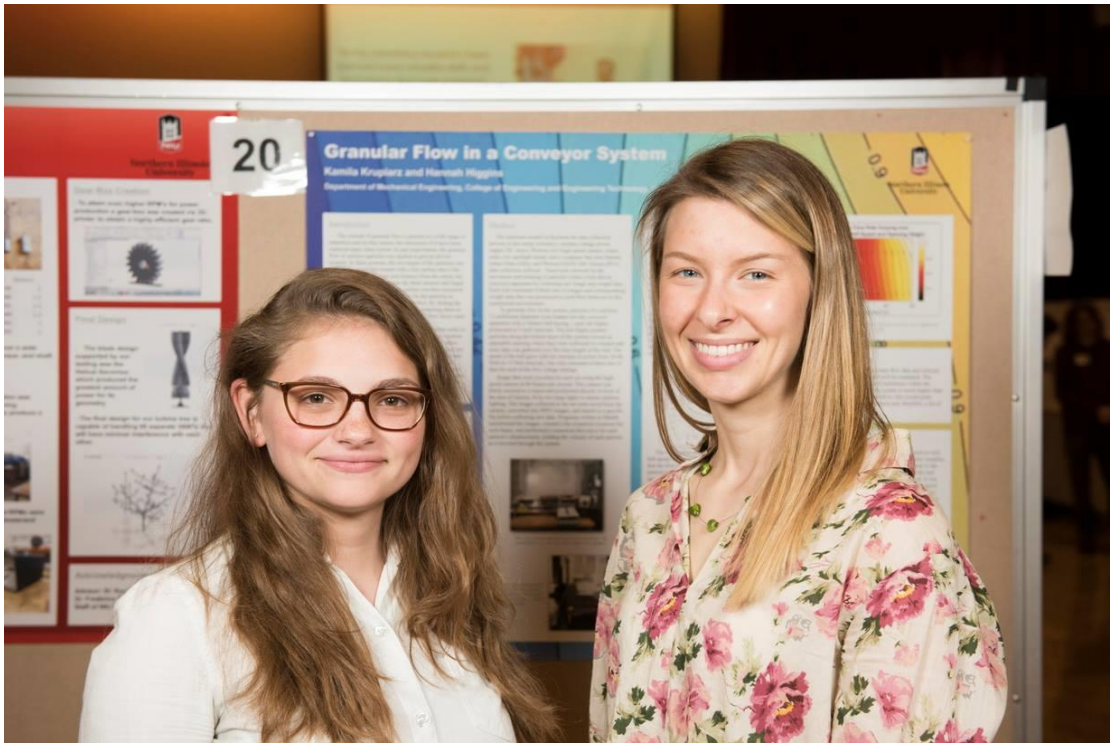

Figure 4: Reearch Rookie mentee and I at URAD in April 2017

Impact on Academic Experience

It was a pleasure to be funded by the SEF in conducting research this past semester. I believe that as much as my presence may have impacted my mentee, her presence impacted me on a positive level very much! It was so fun to work in the lab with her, see the new ideas she had for computer programming, and even take our work to places in the area, like Common Grounds, helping her to explore the local DeKalb area and potentially feel more at home here. I think that mentoring is most-definitely a beneficial experience for both people and helps each person see a problem with many different perspectives with one unifying goal. It's even better when this goal is a technical one that helps advance an academic field.