ABSTRACT

Biorefineries rely on compression feed screws to transport biomass for biofuel production in chemical reactors. However, flowability issues within these feedscrews often lead to production downtime, impacting profitability. Modeling biomass flow within the feedscrews is crucial to optimize processing parameters like torque and speed, reducing downtime.

Biomass is a non-uniform granular material which faces flowability issues. The problems in flowability is influenced by factors such as particle size, moisture content, material composition, and processing methods. Identifying key parameters that can influence the material behavior is vital to minimize production downtimes.

Feedscrews operate under high pressures which makes obtaining accurate material parameters at these high pressures challenging. Many methods used within the pharmaceutical industry to obtain material parameters are unable to reach the larger pressures that the material experiences within the feedscrew. However, Triaxial testing can be used to test the material at the high pressure of interest. Triaxial testing has been used within the civil engineering field to test granular materials such as soils, sand, and rocks.

The Finite Element Method (FEM) using a continuum model is used for modeling systems with a large number of particles. The modified Drucker-Prager Cap (mDPC) continuum model is often used to capture complex material behavior, including densification and shear yielding in granular materials. This model seems well suited to capture the behaviors of biomass material.

The focus of the thesis is to obtain the shear failure properties of corn stover using triaxial testing and the Drucker-Prager Cap continuum model. Simulations and experimental data are utilized to establish a criterion for identifying shear failure. While simulations depict ideal behavior of a DPC material with frictionless and frictional platens, experimental data shows trends of real-life corn stover.

Simulation results effectively predict the material's friction angle but show larger errors in estimating cohesion, potentially due to extrapolation or cohesion's sensitivity to volumetric plastic strain. Further simulations at smaller hydrostatic unloading pressures are recommended to reduce this error. Experimental trends for shear failure seem to align

with simulation trends for shear failure identification. However, the densification trends in experiments lack the clarity observed in the trends from the simulations. More triaxial experiments should be run to determine if the trends are consistent at other hydrostatic loading and unloading pressures. More than two experiments at the same hydrostatic loading pressure should also be run to estimate the shear failure line to obtain a better estimation. Experimentally there are a number of other factors that could contribute to errors such as the estimated material diameter used to calculate Mises stress, if corrections were made for items such as the moving piston, latex membrane, and more, and how far the shear failure line is extrapolated to the vertical axis.