The project entitled, *Characterization of Mechanical Biomass Particle-Particle and Particle-Wall Interactions*, led by Dr. Hojae Yi, Assistant Research Professor of The Pennsylvania State University, in collaboration with Dr. James H. Dooley, CTO of Forest Concepts, LLC, has an overall goal to determine variability in friction and adhesion of biomass particles relative to tissue type. The bulk mechanical behavior, e.g. storage and handling, of biomass is the manifestation of responses of particles and their interactions at the underlying scales. Among many biochemical and mechanical interactions, friction and adhesion are thought to be the two dominant interactions between biomass particles or particle-wall surfaces affecting the biomass flow, which is a key mechanical phenomenon describing biomass handling. These biomass particle interactions are thought to vary across tissue types. Such differences contribute to the variability of bulk biomass behavior and the consequent challenges to the reliable biomass handling.

Unlike clean-chip feedstocks, forest residue biomass includes a mix of particles comprised of bole wood, bark, needles, twigs, etc. Therefore, we expect that forest residues will have different flow behavior for the same particle size than clean bole-wood particles. For example, the bark is much spongier, and needles are pitchy. The resulting biomass flow behavior will vary due to differences between anatomical origin and the percentage of each fraction in the bulk biomass. This study also intends to use corn stover, a complex bulk material that has properties influenced by anatomical content such as rind, pith, nodes, leaves, and cobs. Forest Concepts will procure experimental materials for source and location-specific corn stover and southern pine forest residues. Forest Concepts will mill commingled and pure lots of anatomical fractions into research samples. For a handling system wall material, one of the most commonly used steel will be selected.

Penn State and Forest Concepts will determine friction and adhesion between biomass particles and particle-wall surfaces using Penn State’s in-house Micro-Mechanical Extensometer (MME). Penn State’s MME can accommodate test specimens of several millimeters in size that is typical to biomass particles. The fundamental concept of MME’s is to integrate a sample mounting, a force application, and a displacement sensing mechanism into a single device. MME tests are performed with an integrated imaging system allowing the subsequent image analysis to determine the force-displacement responses. Images will be analyzed using an in-house Digital Image Correlation code that accounts for the characteristic low-contrast images of plant-based materials.

Leveraging the knowledge and existing MME set-up, the Penn State and Forest Concept team will focus on a detailed and inclusive experimental design. Taking advantage of Forest Concepts’ ability to characterize the anatomical fractions, Penn State team will conduct a set of experiments with representative samples of the most common tissue types by volume or weight.

Penn State and Forest Concepts will use Cubical Triaxial Testers to determine fundamental mechanical properties of analytical biomass flow models. This study will evaluate the mechanical behavior of anatomical fractions independently, then the same material blended in realistic proportions based on Forest Concepts data from operational sites. Correlations between MME tests and bulk biomass properties will provide an insight into how biomass flow behaviors arise from biomass particles interactions and particle-wall surfaces at underlying scales. Moreover, the MME tests will provide novel mechanical properties of biomass particles that can be directly used in a Discrete Element models of biomass handling.