

EXPERIMENTAL AND NUMERICAL INVESTIGATION OF BIOMASS MECHANICAL PRE-PROCESSING

Bo Liu

Dr. Ali Bulent Koc, Dissertation Supervisor

ABSTRACT

In this study, mechanical properties of switchgrass and miscanthus were determined by tensile, compressive and shear tests in longitudinal (along the fiber) and transversal (cross the fiber) directions with special designed tools. A linear cutting platform and a data acquisition system were developed to investigate the biomass cutting performances using conventional cutting and ultrasonic-assisted cutting. Three different blades with 20 kHz vibration frequency were designed by using finite element analysis and verified by experimental modal analysis. Finite element analysis models of biomass cutting were developed to simulate the biomass cutting process. The simulation results shed light on cutting parameters need to be chosen in cutting experiments as well as the ultrasonic blade designs. Biomass cutting experiments were carried out to investigate the effects of cutting speeds, shear angles, blade profiles and ultrasonication on the cutting force and energy consumption during switchgrass and miscanthus cutting. Compared to the conventional cutting method, ultrasonic-assisted cutting reduced the total energy consumption (cutting energy plus energy consumption for ultrasonication) about 50% when the cutting speed was about 100 mm/s. When the cutting speed reached the speed of ultrasonic vibration (300 mm/s), the ultrasonic cutting started to have no effect on the cutting force. For biomass conventional cutting, the tested cutting speeds did not show obvious effects on cutting performances.