ESTIMATING PRODUCT COMPOSITION AND THERMAL DYNAMICS IN A CONTINUOUS FEED BIOMASS TORREFIER

Waste to Wisdom: Subtask 3.3

Biofuels and Biobased Product Development

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Abstract

This thesis considers results from the torrefaction of woody biomass species including redwood, tanoak, hardwood slash, Douglas fir and Douglas fir tops. The torrefier studied is a pilot-scale continuous feed electrically heated screw conveyance reactor used by the Schatz Energy Research Center (SERC). The thesis analyzed proximate analysis data finding that as degree of torrefaction increases (mass yield decreases), the volatile matter mass fraction decreases, the fixed carbon mass fraction increases and the ash mass fraction stays roughly constant. The proximate analysis data used two different models to predict elemental composition for the raw and torrefied biomass. The elemental composition was used to attempt and estimate the quantity and composition of the products leaving in gaseous phase, of which there is little experimental data. Assuming the gaseous product is primarily composed of carbon monoxide, carbon dioxide and water vapor, it is found that air must have entered the reactor to fulfill an elemental balance. This confirms observations of combustion seen during experimentation, with the assumption that air is entering through the airlocks. An error analysis was conducted on previously calculated higher heating values. A sensitivity analysis showed that temperature was the most influential parameter when determining higher heating values. Variation (standard deviation) for the higher heating values was found using first order error propagation and showed that feedstock was not a statistically significant parameter. Lastly, this thesis designed a thermal model depicting the thermal dynamics occurring to constituents in the torrefier during torrefaction. Thermal data gathered from thermocouples placed along the length of the torrefier are used as reference for the model. Air and product temperatures were measured. The current model has been tuned by hand with the aim of reducing the sum of the squared residuals between the experimental data and the modeled values. The current model is able to predict most of the dynamics found in the raw data; however, only part of the reactor has been modeled. Future work includes modeling the rest of the reactor, making some changes to the model and optimizing the model by using an unconstrained cost function in MATLAB to tune parameters.