PYTHON-BASED PROCESS MODELLING AND OPTIMIZATION OF PYROLYSIS VALORIZATION OF PALM KERNEL SHELLS AND EMPTY FRUIT BUNCHES FOR BIOCHAR PRODUCTION

MWV-020

https://dx.doi.org/10.4314/just.v44i2.6s

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Abstract

The valorization of palm oil processing residues — particularly palm kernel shells (PKS) and empty fruit bunches (EFB) — through pyrolysis offers a dual benefit of waste reduction and bioenergy/biochar production. This study develops a Python-based process model to simulate and optimize the pyrolysis of PKS and EFB under varying temperature profiles (350–700°C), residence times, and heating rates. The model integrates kinetic data derived from TGA experiments with mass and energy balance calculations to predict biochar yield, calorific value, and carbon content as functions of process parameters. Sensitivity analysis identifies temperature and feedstock moisture content as the dominant variables affecting biochar quality. Model-predicted optima were validated experimentally, showing close agreement (less than 5% deviation). The biochar produced at optimized conditions met ASTM standards for soil amendment applications. This computational tool provides a scalable framework for pyrolysis process design applicable to other agro-industrial residues.

Keywords: Pyrolysis, palm kernel shells (PKS), empty fruit bunches (EFB), fresh fruit bunches (FFB), process optimization, circular economy.