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Energy Self-Sufficiency in Municipal Sewage Sludge Pyrolysis: A Simulation Study

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Abstract

The sustainable management of municipal sewage sludge (MSS) remains a critical challenge, requiring innovative approaches grounded in circular economy principles. This study focuses on the simulation of an energy self-sufficient pyrolysis system for MSS using SuperPro Designer. The primary objective is to achieve a self-sustaining thermal balance, in which the energy content of the generated syngas and bio-oil offsets the total heat demand of the integrated drying and carbonization stages. A one-at-a-time (OAT) sensitivity analysis was conducted to evaluate the influence of core operational variables on energy self-sufficiency. Specifically, the simulation investigates the effects of target moisture content after drying and the distribution of pyrolysis product yields on the overall mass-energy balance. Unlike conventional energy-intensive disposal methods, this model identifies the specific operational thresholds required to eliminate reliance on external fuel sources. By quantifying the trade-offs between drying energy consumption and product-driven thermal recovery, the findings provide a robust theoretical framework for scaling up sludge-to-energy facilities. This research provides a strategic roadmap for optimizing pilot-scale implementations of carbon-neutral waste processing.

Keywords: Municipal Sewage Sludge, Pyrolysis, Energy Self-Balance, Simulation, Waste-to-Energy

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