WasteWood2Fuel – Development of a technology for the decentralised synthesis of liquid fuels from solid biogenic residues

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Abstract

In the context of global energy transition, synthetic fuels derived from renewable carbon sources are seen as indispensable for defossilizing sectors such as aviation, maritime transport, and heavy-duty logistics, where direct electrification is not feasible. The WasteWood2Fuel project addresses this need by developing a decentralized, modular process chain for the conversion of biogenic waste wood into synthetic fuels. The technological approach combines oxygen-enriched fixed-bed gasification, advanced gas cleaning, and downstream catalytic synthesis of methanol and Fischer–Tropsch (FT) hydrocarbons. The focus is on scalable process modules that enable regional value creation using locally available biomass and renewable electricity.

Within this project, the Chair of Chemical Engineering (CVT) at the University of Bayreuth focuses on the Fischer–Tropsch synthesis step. An oil-cooled single-tube fixed-bed reactor (30 mm ID and 1000 mm bed length) has been designed and manufactured to provide realistic thermal boundary conditions and representative flow regimes. Several catalysts are investigated experimentally with respect to CO conversion, hydrocarbon selectivity (CH_4 vs. C_2^+), and temperature profile formation under varying syngas compositions and space velocities.

Complementary to the experimental campaign, a detailed reactor model has been developed. It includes coupled heat and mass balances, accounts for pressure drop as well as axial variation of molar flow due to reaction stoichiometry. The model also incorporates the dependency of radial heat conductivity and wall heat transfer coefficients on local gas velocities. These aspects have been shown to significantly impact the accuracy of predictive simulations, as demonstrated in recent work by Jess and Kern [1,2].

Validation of the model is in preparation using data from the single-tube reactor, with the goal of transferring insights to the design of market-appropriate size modules. In the long term, such systems could play a key role in securing renewable fuel supply chains for sectors with no alternative to chemical energy carriers.

References

[1] Jess, A.; Kern, C. Significance of Pressure Drop, Changing Molar Flow, and Formation of Steam in the Accurate Modeling of a Multi-Tubular Fischer–Tropsch Reactor, Processes, 2023, 11, 3281.

[2] Kern, C.; Jess, A. Improvement of a Multi-Tubular Fischer–Tropsch Reactor with Gas Recycle by Appropriate Combination of Axial Activity Distribution and Gas Velocity, Catal. Sci. Technol., 2023, 13, 2212–2222.