Technical evaluation of methanol production from CO_2 and H_2 via integrated renewable-based routes using AVEVA Process Simulation

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ABSTRACT

A greenfield project involves the complete conception and implementation of chemical processes designed from the ground up, enabling the integration of modern technologies and advanced modeling strategies. Such projects allow detailed process design, accurate utility sizing, and robust techno-economic feasibility assessments without constraints imposed by existing infrastructure. In this context, process simulation plays a central role in evaluating technological routes and supporting decision-making during early design stages. In this work, a methanol production plant was developed using AVEVA Process Simulation, considering CO_2 and H_2 obtained from potentially renewable-based processes, namely biomass gasification and dry reforming of methane. These pathways were selected for their potential to valorize carbon-containing feedstocks and mitigate greenhouse gas emissions when coupled with renewable energy sources. Biomass gasification converts renewable solid feedstocks into synthesis gas, while dry reforming of methane utilizes CO_2 and CH_4 to produce syngas suitable for downstream applications. Previous studies in the literature identify carbon capture and utilization (CCU), as implemented in this study, as a central pillar of the methanol economy and a promising alternative to conventional carbon capture and storage (CCS). Reaction sets implemented in the gasifier, reverse water–gas shift reactor, dry reforming reactor, and methanol synthesis reactor were adopted from literature. The equation-oriented model employs customized unit operation blocks based on reported kinetics and equilibrium expressions. The study evaluates methanol revenue, energy consumption, operating costs, mass and energy balances, carbon efficiency, and overall project profitability. Results demonstrate the applicability of AVEVA Process Simulation for integrated plant modeling, sustainable process assessment and techno-economic feasibility. Ongoing works are focused on implementation refinements and expanded performance indicators.

Keywords: AVEVA Process Simulation, methanol, techno-economic assessment, DRM, biomass gasification

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