

Exergy Analysis of a Green Dimethyl Ether Production Plant

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Abstract : CO₂ capture and utilization (CCU) is a promising approach to reduce GHG (greenhouse gas) emissions. Many technologies in this field are recently attracting attention. However, since CO₂ is a very stable compound, its utilization as a reagent is energetic intensive. As a consequence, it is unclear whether CCU processes allow for a net reduction of environmental impacts from a life cycle perspective and whether these solutions are sustainable. Among the tools to apply for the quantification of the real environmental benefits of CCU technologies, exergy analysis is the most rigorous from a scientific point of view. The exergy of a system is the maximum obtainable work during a process that brings the system into equilibrium with its reference environment through a series of reversible processes in which the system can only interact with such an environment. In other words, exergy is an “opportunity for doing work” and, in real processes, it is destroyed by entropy generation. The exergy-based analysis is useful to evaluate the thermodynamic inefficiencies of processes, to understand and locate the main consumption of fuels or primary energy, to provide an instrument for comparison among different process configurations and to detect solutions to reduce the energy penalties of a process. In this work, the exergy analysis of a process for the production of Dimethyl Ether (DME) from green hydrogen generated through an electrolysis unit and pure CO₂ captured from flue gas is performed. The model simulates the behavior of all units composing the plant (electrolyzer, carbon capture section, DME synthesis reactor, purification step), with the scope to quantify the performance indices based on the II Law of Thermodynamics and to identify the entropy generation points. Then, a plant optimization strategy is proposed to maximize the exergy efficiency.

Keywords : green DME production, exergy analysis, energy penalties, exergy efficiency

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