Multi-objective Optimization of a New Sustainable Methanol Plant with Cogenerated Energy

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Abstract

Contemplating the situation of biofuels, the objective of this work is to investigate the techno-economic feasibility of methanol synthesis using carbon dioxide captured as an output of fermentation process in bioethanol production distilleries, carrying out an integrated analysis of the overall system. Up to now, studies limited to evaluate the methanol production hydrogenating CO_2 from fossil sources. Systems assessed in this perspective usually are not economically viable due to the high cost associated to obtain hydrogen. In this work, we designed a new sustainable methanol production process from a renewable source. Aiming to promote the advancement and applicability of carbon capture processes, an industrial methanol plant was modeled in Aspen Plus®. The hydrogen required was produced electrolyzing treated water of the distilleries, producing oxygen as a valuable byproduct. Design parameters were manipulated taking into account the associated capital costs and applying factorial design and sensitivity analysis techniques. The response surfaces were obtained according to the amount of bagasse used to cogenerate energy, which has a direct relation with the objective function, attempting to minimize the total annualized costs and the CO_2 Net of the scenario. The results show that the problem of high-energy consumption for the production of hydrogen via electrolysis was bypassed using co-generated energy, being possible and viable to synthesize this process in distilleries able to emit more than 350,000 ton/year of CO_2 with enough cogeneration plants installed. The gross profits obtained by this process are derived from the methanol and oxygen produced being significantly superior by a factor of 4.5 compared to sale of electricity and 8.0 for sale of pure hydrogen. The designed plant led us to conclude that this improved process can be implemented and is an innovative option for carbon mitigation, contributing to the sustainable production of methanol.

Keywords: *Ethanol distillery, Optimization, Methanol synthesis, Cogeneration; Hybrid models.*