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Green Methanol Production Process

PEP Review 2020-07

December 2020

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Abstract

This review presents a techno-economic analysis of a generic green methanol production process. The overall process essentially consists of three different technologies including: (1) CO_2 extraction from atmospheric air; (2) H_2 production from water electrolysis using renewable electricity; and (3) Methanol production using a boiling water-cooled methanol converter. By common definition, the green methanol refers to methanol produced through a production process that emits zero or minimal amount of carbon dioxide (and other greenhouse substances) into the environment during production. Technologies for green methanol production, which have been proposed or are in the emerging stage at the moment, are technically and environmentally different from the modern day, fossil-based methanol technologies that are cheaper to build and operate. But, these technologies can produce 0.5–3.0 ton of CO_2 per ton of methanol, depending on the type of carbon-bearing materials used as fuels and raw materials.

Due to the commercial importance of methanol as a chemical and potential energy source, and in the light of its growing demand resulting from its commercial versatility, concerns about the carbon footprint of the methanol industry are growing—especially regarding the coal-based methanol production processes. An advantage of methanol is that it is a product of CO_2 formed through a reaction of CO_2 with H_2. Hence, methanol is intrinsically a CO_2-neutral material (i.e., it takes one mole of carbon as CO_2 from an outside source in its formation and emits the same into the atmosphere on combustion, or donates its carbon to another material in a chemical reaction). The methanol production process, however, is not carbon neutral on an overall basis as it consumes some form of utilities that are generated from fossil fuels.

Essentially, there are two ways to reduce or eliminate CO_2 emission from a methanol production process; the first way is to use a production technology, which does not utilize an external carbon-bearing source as a carbon donor, or one that would not generate CO_2 as a by-product in the process; the second option is to use carbon-bearing fuel/raw materials and capture/remove CO_2 emitting from the downstream side of process. There is a possibility of a hybrid case also. In this case, the process is based on CO_2 that is extracted partly from the air (instead of from a carbon source like NG, coal, or biomaterial) and partly from the recycled CO_2 generated in the steam production process. This steam is needed for process thermal needs. H_2 is produced from water by an electrolysis process using renewable electricity. Overall, the process is CO_2-negative and extracts a lot more CO_2 from the air than it injects back into the atmosphere.

This review presents a techno-economic evaluation of green methanol process based on the hybrid design.

The analysis of the technology is based on a simulated design of a hypothetical green methanol plant of 150 Mtpd (metric tons per day) capacity. Different aspects of the technology have been analyzed and the analysis results, depending on the feature of technology, are presented in descriptive, tabulated, or diagrammatic formats. Main elements/sections of the technology analysis include: selection and statement of assumptions/bases for process design, process design details (process description with a

complete statement of process operating conditions, material and energy balance, process flow diagram, process discussion, process equipment listing with sizes, utilities summary), and lastly, capital and production economics for three capacity levels—75 Mtpd, 150 Mtpd, and 300 Mtpd.

IHS Markit PEP is of the opinion that, currently, the economics of such a green methanol plant (read details of analysis inside) are not compatible with those of conventional methanol processes. There are, however, certain ways that can make the green process economically closer to the conventional process, in which details about it are described in the review.

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