World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:11, No:11, 2017

CO2 Utilization by Reverse Water-Shift and Fischer-Tropsch Synthesis for Production of Heavier Fraction Hydrocarbons in a Container-Sized Mobile Unit

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Abstract : Carbon capture and utilization (CCU) are one of the key topics in mitigation of CO2 emissions. There are many different technologies that are applied for the production of diverse chemicals from CO2 such as synthetic natural gas, Fischer-Tropsch products, methanol and polymers. Power-to-Gas and Power-to-Liquids concepts arise as a synergetic solution for storing energy and producing value added products from the intermittent renewable energy sources and CCU. VTT is a research and technology development company having energy in transition as one of the key focus areas. VTT has extensive experience in piloting and upscaling of new energy and chemical processes. Recently, VTT has developed and commissioned a Mobile Synthesis Unit (MOBSU) in close collaboration with INERATEC, a spin-off company of Karlsruhe Institute of Technology (KIT, Germany). The MOBSU is a multipurpose synthesis unit for CO2 upgrading to energy carriers and chemicals, which can be transported on-site where CO2 emission and renewable energy are available. The MOBSU is initially used for production of fuel compounds and chemical intermediates by combination of two consecutive processes: reverse Water-Gas Shift (rWGS) and Fischer-Tropsch synthesis (FT). First, CO2 is converted to CO by high-pressure rWGS and then, the CO and H2 rich effluent is used as feed for FT using an intensified reactor technology developed and designed by INERATEC. Chemical equilibrium of rWGS reaction is not affected by pressure. Nevertheless, compression would be required in between rWGS and FT in the case when rWGS is operated at atmospheric pressure. This would also require cooling of rWGS effluent, water removal and reheating. For that reason, rWGS is operated using precious metal catalyst in the MOBSU at similar pressure as FT to simplify the process. However, operating rWGS at high pressures has also some disadvantages such as methane and carbon formation, and more demanding specifications for materials. The main parts of FT module are an intensified reactor, a hot trap to condense the FT wax products, and a cold trap to condense the FT liquid products. The FT synthesis is performed using cobalt catalyst in a novel compact reactor technology with integrated highly-efficient water evaporation cooling cycle. The MOBSU started operation in November 2016. First, the FT module is tested using as feedstock H2 and CO. Subsequently, rWGS and FT modules are operated together using CO2 and H2 as feedstock of ca. 5 Nm3/hr total flowrate. On spring 2017, The MOBSU unit will be integrated together with a direct air capture (DAC) of CO2 unit, and a PEM electrolyser unit at Lappeenranta University of Technology (LUT) premises for demonstration of the SoletAir concept. This would be the first time when synthetic fuels are produced by combination of DAC unit and electrolyser unit which uses solar power for H2 production.

Keywords : CO2 utilization, demonstration, Fischer-Tropsch synthesis, intensified reactors, reverse water-gas shift
Conference Title : ICCD 2017 : International Conference on Carbon Dioxide
Conference Location : Venice, Italy
Conference Dates : November 13-14, 2017