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Design and Fabrication of the First Commercial-Scale Liquid Phase Methanol (LPMEOH™) Reactor

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Abstract

The Liquid Phase Methanol (LPMEOH™) process uses a slurry bubble column reactor to convert synthesis gas (syngas), primarily a mixture of carbon monoxide and hydrogen, to methanol. Because of its superior heat management, the process can utilize *directly* the carbon monoxide (CO)-rich syngas characteristic of the gasification of coal, petroleum coke, residual oil, wastes, or other hydrocarbon feedstocks.

The LPMEOH™ Demonstration Project at Kingsport, Tennessee, is a $213.7 million cooperative agreement between the U.S. Department of Energy (DOE) and Air Products Liquid Phase Conversion Company, L.P., a partnership between Air Products and Chemicals, Inc. and Eastman Chemical Company, to produce methanol from coal-derived syngas. Construction of the LPMEOH™ Process Demonstration Plant at Eastman's chemicals-from-coal complex in Kingsport was completed in January 1997. Following commissioning and shakedown activities, the first production of methanol from the facility occurred on April 2, 1997. Nameplate capacity of 260 short tons per day (TPD) was achieved on April 6, 1997, and production rates have exceeded 300 TPD of methanol at times.

This report describes the design, fabrication, and installation of the Kingsport LPMEOH™ reactor, which is the first commercial-scale LPMEOH™ reactor ever built. The vessel is 7.5 feet in diameter and 70 feet tall with design conditions of 1000 psig at 600 °F. These dimensions represent a significant scale-up from prior experience at the DOE-owned Alternative Fuels Development Unit in LaPorte, Texas, where 18-inch and 22-inch diameter reactors have been tested successfully over thousands of hours. The biggest obstacles discovered during the scale-up, however, were encountered during fabrication of the vessel. The lessons learned during this process must be considered in tailoring the design for future sites, where the reactor dimensions may grow by yet another factor of two.

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Acronyms and Definitions

Air Products	-	Air Products and Chemicals, Inc.
AFDU	-	Alternative Fuels Development Unit, the DOE-owned experimental unit located adjacent to Air Products' industrial gas facility at LaPorte, Texas, where the LPMEOH™ process was successfully piloted.
Balanced Gas	-	A syngas with a composition of hydrogen (H_2), carbon monoxide (CO), and carbon dioxide (CO_2) in stoichiometric balance for the production of methanol.
BFW	-	boiler feed water
CO Gas	-	A syngas containing primarily carbon monoxide (CO).
DOE	-	United States Department of Energy
DP	-	differential pressure
Eastman	-	Eastman Chemical Company
ESD	-	emergency shutdown
Gas Holdup	-	The percentage of three-phase slurry volume in the reactor that is occupied by gas.
H_2 Gas	-	A syngas containing an excess of hydrogen (H_2) over the stoichiometric balance for the production of methanol.
IGCC	-	Integrated Gasification Combined Cycle, a type of electric power generation plant.
Inlet Superficial Velocity	-	The ratio of the actual cubic feet of gas at the reactor inlet (calculated at the reactor temperature and pressure) to the reactor cross-sectional area (excluding the area contribution by the internal heat exchanger); typical units are feet per second.
LPMEOH™	-	Liquid Phase Methanol (the technology to be demonstrated)
MAWP	-	maximum allowable working pressure
NDG	-	nuclear density gauge
OD	-	outside diameter
psi (or #)	-	pounds per square inch
psia	-	pounds per square inch (absolute)
psig	-	pounds per square inch (gauge)
PWHT	-	post-weld heat treatment
Recycle Gas	-	The portion of unreacted syngas exiting the reactor that is recycled as a feed gas.
RTD	-	resistance temperature device
Sl/hr-kg	-	standard liters per hour per kilogram of catalyst
Syngas	-	abbreviation for synthesis gas
Syngas Conversion	-	The percentage of syngas consumed across the reactor.
Synthesis Gas	-	A gas containing primarily hydrogen (H_2) and carbon monoxide (CO); intended for "synthesis" in a reactor to form methanol and/or other hydrocarbons (synthesis gas may also contain CO_2, water, and other gases).
TPD	-	(short) tons per day
wt%	-	weight per cent