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Carbon Monoxide Production from Syngas via Cryogenic Partial Condensation Process

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Jonny Goyal
Principal Analyst

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Abstract

Carbon monoxide is an industrial gas that has many applications in bulk chemicals manufacturing. Over 90% of carbon monoxide is used in the form of synthesis gas (or syngas) for the production of ammonia, hydrogen, and methanol. The rest is consumed directly as carbon monoxide for the production of phosgene ($COC1_2$), acrylic acid (CH_2=CHCOOH), acetic acid (CH_3COOH), dimethyl formamide, propionic acid, pivalic acid, and many other copolymers. These bulk chemicals have a large market and thus play an important role in a country's economy.

Typically, carbon monoxide coexists with hydrogen as a mixture gas. To obtain pure carbon monoxide (CO), it is separated from the mixture gas. Different technologies are used, such as cryogenic separation, pressure swing adsorption, membrane separation, and salt solution absorption. The design of a particular system is determined primarily by the feed gas composition, inlet pressure, and by the purity and pressure specifications for the separated gases. The design also depends on whether the process objective is to minimize energy requirements or capital cost or to optimize both; considerable variation is possible in the number and arrangement of equipment configuration, heat interchange, and expansion and/or compression steps.

The cryogenic partial condensation process is one well-defined and widely used commercial route to carbon monoxide (CO) production. This process produces commercial-grade carbon monoxide (98–99% purity) and also hydrogen (97–98% purity). While the simplicity of this process makes it attractive, its refrigeration requirement is significant. This PEP review focuses on the cryogenic partial condensation process using syngas from different sources: one from steam methane reforming (with the H_2:CO ratio at 3:1) and another from coal gasification (with the H_2:CO ratio at 1.8:1). The purpose of taking two different H_2:CO sources is to design a system that can widely accept the variation in syngas composition while keeping the same equipment configuration with minimal energy and capital cost requirements.

Our design is based on technical information and data available from patents assigned to Linde, Air Liquide, Air Products and Chemicals, etc., as well as different literature surveys. The design provided in this report is based on a typical Linde technology approach with some equipment restructure. The cryogenic partial condensation process is reviewed, the industry status of carbon monoxide is updated, and a summary is provided of both cases in terms of comparative economics.

While the process presented herein is PEP's independent interpretation of the companies' patent literature and may not reflect in whole or in part the actual plant configuration, we do believe that they are sufficiently representative of plant conceptual process designs.

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Americas: +1 800 IHS CARE (+1 800 447 2273); CustomerCare@ihs.com
Europe, Middle East, and Africa: +44 (0) 1344 328 300; Customer.Support@ihs.com
Asia and the Pacific Rim: +604 291 3600; SupportAPAC@ihs.com