PEP Review 2011-14
METHANOL PRODUCTION VIA TOYO PROCESS
By
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ABSTRACT

This Review updates PEP Review 2001-14 by presenting a techno-economic evaluation of a methanol production process based on technical information/data available in the patents and technology brochures of Toyo Engineering Corporation. One major difference in the design presented in this Review from the one in PEP Review 2001-14 is that natural gas (NG) reforming is based upon Toyo’s steam reforming technology instead of the combined reforming technology that was used for the design presented in PEP Review 2001-14. Another notable difference is in the design of the heat recovery system from flue gas which, in this Review, is exactly according to Toyo’s scheme in terms of configuration of the heat recovery process. Also Toyo has just one steam methane reformer and one methanol reactor for a 5,000 metric TPD capacity methanol plant. The flowsheet of our process is almost identical to one presented in Toyo’s technology brochures. The base capacity of the plant is also the same, i.e., 5,000 metric TPD. The plant consists of a single train of major equipment (e.g., steam-methane reformer, methanol converter, distillation columns, etc.).

The process essentially consists of steam reforming of desulfurized NG preferably in a proprietary top-fired steam-methane reformer. The energy required for the endothermic reaction of steam and hydrocarbons present in the NG is supplied from combustion of NG (as fuel) and process purge streams. The combustion gases leaving the radiant zone of the reformer are still at a high temperature; they pass through a convective zone in which they usefully transfer their thermal energy by preheating the reformer feed stream, the prereformer feed stream, the NG feed stream, and the combustion air feedstream. A steam production zone, positioned in the middle of these four preheating zones, is also included in the flue gas heat recovery circuit. Prior to reforming, the NG generally goes through an adiabatic prereforming step at 932–1,202°F (500–650°C). Typically, the steam reforming temperature range is 1,382–1,607°F (750–875°C) at 15–30 atm pressure. The steam-to-carbon molar ratio in the reformer feed is between 2.5 and 3.5. Overall methane conversion in the reforming process is 80–90%. Toyo’s design can include use of an alumina-supported, nickel-based reforming catalyst prepared by catalyst manufacturers like Haldor Topsøe, Süd Chemie, etc., or its own catalyst developed for its proprietary reforming process known as the Innovative Steam Reforming Optimized Process (ISOP). ISOP catalyst has been used in several plants producing hydrogen, ammonia and methanol. According to Toyo, the ISOP catalyst can reduce the size of the reformer by 10–20%. Toyo has also constructed steam reformers of other licensors (KBR, UOP, KTI, etc.).

Syngas, formed above, is cooled and water condensate is removed therefrom. Thereafter, the gas is compressed at about 100 atm and fed to Toyo’s proprietary methanol converter (known as a MRF-Z® reactor). This reactor has specific features of multistage indirect cooling and radial flow capability for syngas. Toyo claims that its reactor can produce a higher quantity of methanol per unit volume as compared to reactors of other licensors. The heat of reaction is removed from the reactor in generating MP steam. The reaction temperature is 464–500°F (240–260°C). The catalyst is a copper-based compound, promoted by ZnO. Al₂O₃ is another notable ingredient of the catalyst. The reactor effluent stream is partially condensed. The uncondensed gaseous part is separated from the condensate, and recycled to the methanol reactor after recompression. A small portion of the recycle gas is also purged to avoid buildup of inerts in the process. Methanol is separated from water in purified form using a battery of two distillation towers.
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