Application Note

Methanol production analytics overview

Methanol production and main uses The methanol industry spans the entire globe, with production in Asia, North and South America, Europe, Africa and the Middle East. Worldwide, over 90 methanol plants have a combined production capacity of about 100 million metric tons (almost 33 billion gallons or 90 billion liters), and each day more than 100,000 tons of methanol is used as a chemical feedstock or as a transportation fuel (60 million gallons or 225 million liters). Methanol is also a truly global commodity, and each day there are more than 80,000 metric tons of methanol shipped from one continent to another. Methanol is used to produce acetic acid, formaldehyde, olefins, dimethyl ether (a synthetic fuel) and a number of other chemical intermediates that are utilized to make countless products throughout the global economy – and by volume, methanol is one of the top 5 chemical commodities shipped around the world each year.[1]

The overall methanol production process A typical modern methanol-producing plant based on natural gas as primary feedstock converts the natural gas in a Steam Methane Reformer (SMR) to make-up syngas, a mixture of H_2, CO and CO_2. Alternatively, the syngas can be produced via gasification of a variety of feed stocks, including coal, petroleum coke, oil residues, and biomass. The raw syngas is dried, compressed and converted in a methanol reactor to produce raw methanol, which can be purified, typically via a 3-stage downstream distillation process. The methanol conversion reactions are reversible, and the equilibrium is driven towards the methanol product side by continuously removing methanol condensate in the methanol separator. The gas from the separator is then recycled back and combined with the make-up syngas as part of a synthesis loop. The critical analytical measurements for optimum reactor performance are the relative amounts of H_2, CO and CO_2, used to calculate the module M factor $[(H_2\text{-}CO_2)/(CO+CO_2)]$,which should be maintained typically between 2.1 and 2.3.[2]

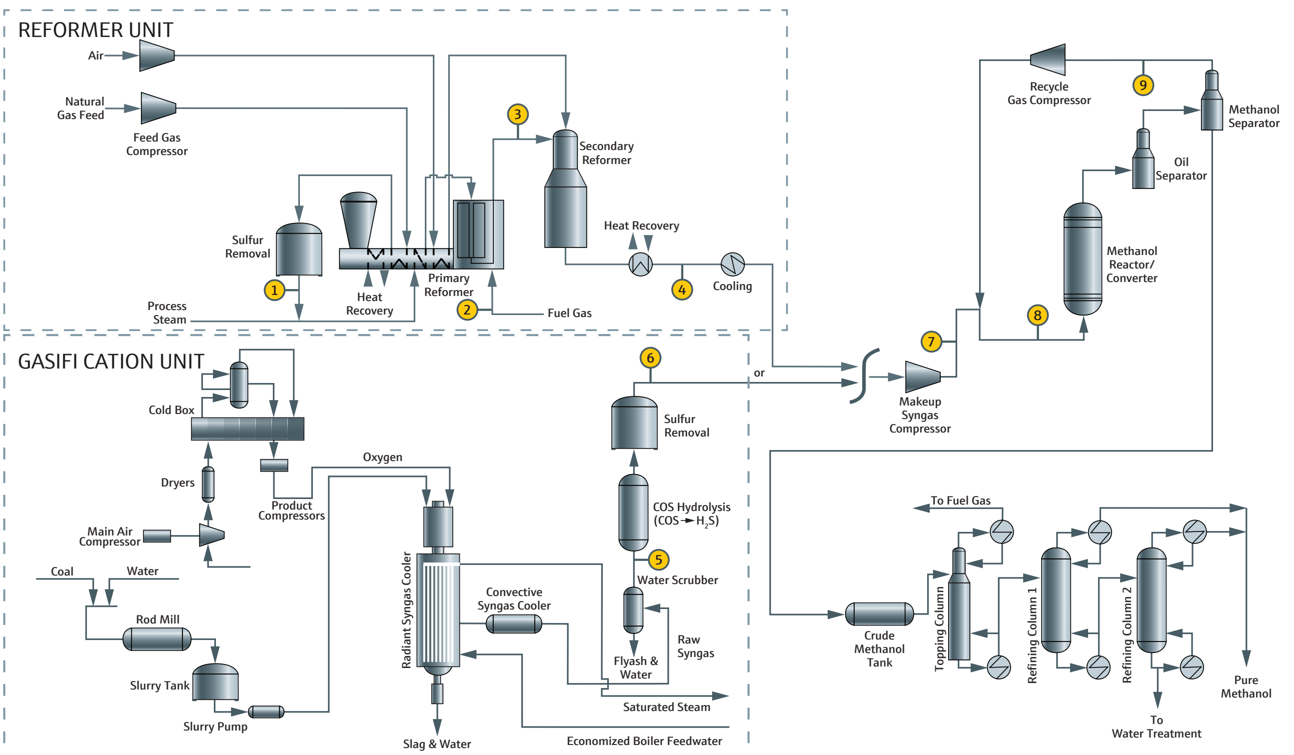

Figure 1: A Simplified Process Diagram Showing the Main Process Units in a Modern Methanol Production Plant

1. The Methanol Industry (2011). Retrieved from http://www.methanol.org/Methanol-Basics/The-Methanol-Industry.aspx.
2. Machado, C., Medeiros, J., Araujo, O., Alves, R., A Comparative Analysis of Methanol Production Routes: Synthesis Gas versus CO2 Hydrogenation, Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management, Bali, Indonesia, Jan 7-9, 2014 (2981-2990).

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Process analytical challenges There are several streams that are typically analyzed in real time during the methanol manufacturing process, and the analysis results form the basis for controlling and optimizing the main process units. Although most of the streams are relatively easy to analyze using traditional on-line analyzer techniques, such as GC, MS, photometry, in several cases steam content and the process conditions are severe enough require special sample conditioning techniques. Examples include effluent streams from the primary and secondary reformers and the high temperature and low temperature shift converters, as well as the raw syngas effluent from a gasifier. With these challenging samples, the ability to obtain reliable sampling and analysis is often compromised. The use of the Optograf Analyzer, combined with the OptoDRS Sampling Interface, is a unique and robust solution for these challenging streams.

The Solution: Optograf™ Analyzer and OptoDRS™ or OptoAST™ system The Optograf Analyzer provides the unique spectroscopic ability to analyze the mononuclear diatomic gases H_2 and N_2, which allows measurement of all the streams shown in the typical "Stream Service" list below. Speciation is achieved without any columns, valves, stream switching or the need for carrier gas. In addition, the OptoDRS and OptoAST modules are based on the pipe-centric concept of performing the process sampling, sample conditioning, and measurement in a single, integrated module that can be installed at the sample tap. Below is a list of typical process conditions and the process sampling interfaces from Kaiser Optical Systems, Inc., for each of the streams analyzed on-line. The OptoDRS sampling module is uniquely capable of dealing with the preconditioning of hot, dirty (particulates) and moisture-saturated samples, such as those found in the reformer and shift-converter streams, whereas the OptoAST module can interface to relatively dry and clean process samples at line temperature and pressure (up to 150˚C/1000 psig). As such, only minimal sample conditioning is required, while avoiding any need for sample transport to the analyzer in a shelter, because the optical probe sensor transmits spectral information via an optical fiber to the analyzer.

	Stream Service	Key Measurement Parameter	Pressure* (barg)	Temp* (˚C)	Recommended Sampling Interface
1	Natural Gas Feed to Primary Reformer**	Carbon Number	26	25	OptoAST
2	Fuel Gas to Reformer Furnaces**	BTU	6	40	OptoAST
3	Raw Syngas – Primary Reformer Outlet**	Composition/CH_4	36	800	OptoDRS
4	Raw Syngas – Secondary Reformer Outlet**	Composition/H_2/CO/CO_2	35	370	OptoDRS
5	Raw Syngas from Gasifier Effluent***	Composition/CH_4	49	337	OptoDRS
6	Syngas after Scrubber***	Composition/H_2/CO/CO_2	49	199	OptoDRS
7	Make-up Syngas	Composition/H_2/CO/CO_2	53	135	OptoAST
8	Syngas to Methanol Reactor	Composition/H_2/CO/CO_2	120	135	OptoAST
9	Methanol Synthesis Loop Recycle	Composition	80	40	OptoAST

Table 1: Summary of the Typical Streams Analyzed On-line in a Methanol Plant (see also Figure 1)

* Pressure and Temperature values listed are for typical process unit outlet streams.
** Syngas from a Steam Methane Reformer.
*** Syngas from a Gasifier.