Methanol: syngas to methanol reactor

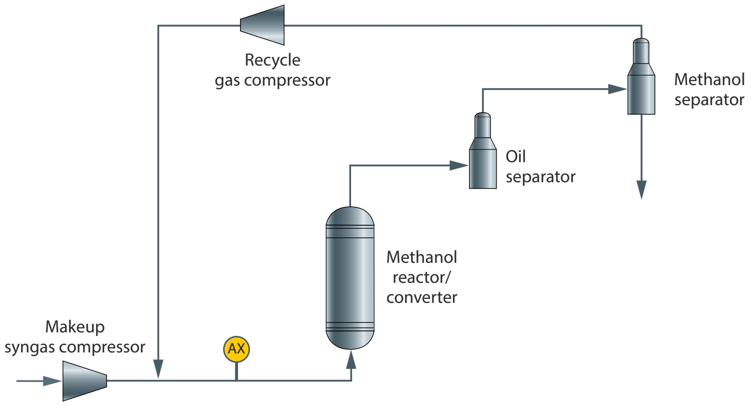

Figure 1: Typical methanol reactor inlet measurement point*

Benefits at a glance

- Unique spectroscopic capability to measure all syngas components, including H_2 and N_2
- Pipe-centric sampling and measurement at the sample tap
- Sample can often be returned to process, avoiding disposal to flare header
- Complete syngas speciation
- No valves, columns, or carrier gas
- No routine calibration
- No interference from moisture

The methanol synthesis process results in a low equilibrium conversion of syngas to methanol, so unconverted syngas is recycled back into the input of the reactor in a synthesis loop. The reaction equilibrium is driven toward the methanol product by removing methanol from the reactor effluent. Recycle syngas is compressed and mixed with make-up gas as reactor feed. Control of the methanol reactor is based on optimizing the stoichiometric concentrations of the reactants in the feed gas stream, often expressed as the modulus (*M*) or stoichiometric number, which is defined as $[H_2\text{-}CO_2]/[CO+CO_2]$. The control target for *M* is between 2.0 and 2.3 for efficient methanol synthesis.

Measurement of methanol reactor feed

The Raman Rxn5 analyzer is a unique integrated sampling and measurement system for the methanol reactor feed syngas stream. A typical Raman spectrum and stream composition for the make-up gas stream is shown in Figure 2. The Raman Rxn5 is especially well suited to make the Modulus M measurement as it can measure all the required components, including the mononuclear diatomics, in a single spectrum with complete speciation. As the Raman Rxn5 is essentially transparent to moisture, any residual moisture leakage after the upstream driers does not interfere with the analysis as long as this residual moisture does not condense. Regardless of moisture content, the analysis results are provided on a dry basis. The Raman Rxn5 also uses a normalized analysis which makes it very robust against pressure and temperature changes as well as any slow fouling that may occur.

Reliability issues with traditional methods for methanol reactor analysis

The syngas feed to a methanol reactor is often analyzed using process gas chromatography (GC) or mass spectrometry (MS). Both technologies require transporting and conditioning the sample at both the sample tap and at the sample conditioning panel close to the analyzer. Due to low sample pressure, it is difficult to return the sample to process, so it must be sent to flare. Protecting the GC or MS analyzers from liquid carryover after the absorber dryer becomes the main sampling system challenge, as this event can damage columns in a GC or the ionization chamber in an MS. The Rxn-30 probe used by the Raman Rxn5 cannot be damaged by liquid carryover.

* See the general Methanol: production analytics overview

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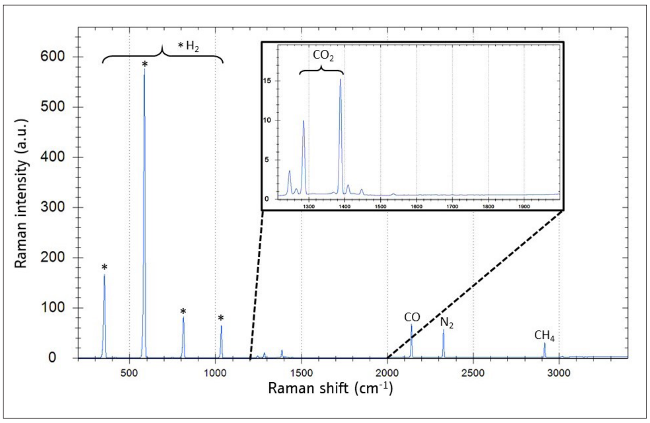

Figure 2. Raman spectrum of a typical methanol reactor inlet stream

Solution: Raman Rxn5 analyzer with the syngas to methanol reactor method

In the case of relatively clean and dry streams like a natural gas feed, the Raman Rxn5 analyzer with an Rxn-30 probe allows for a wide range of sample pressure (70-800 psia typical) and sample temperature (-40 to 150 °C). the Rxn-30 probe can be easily integrated into sample conditioning systems to measure process streams at higher temperatures and pressures. The ability to measure at higher pressures often allows the sample to be returned to the process at a lower pressure sampling point - flaring of the returned sample is avoided. Sampling lag time is essentially zero, as no sample transport is required, increasing the speed of analysis.

The Raman Rxn5 analyzer for syngas to methanol reactor contains the following per measurement point:

- Dedicated laser module
- Rxn-30 fiber optic probe
- Industrial hybrid electro-optical cable (up to 150 m long, customized to your plant requirements)
- Combined pressure and temperature sensor with cable (up to 150 m long, customized to your plant requirements)
- Dedicated syngas to methanol reactor method

Typical process conditions	P (barg)	T (°C)
At sample tap	39	135
At Rxn-30 probe	39	55

Typical stream composition

Component	Range (Mol%)	Normal (Mol%)	Precision (Mol%) k=2	Cal gas (Mol%)	Precision (Mol%) k=2
Hydrogen	40-95	59.9	0.03	64	0.03
Nitrogen	0-35	21.7	0.03	16	0.02
Carbon monoxide	0-35	14.6	0.02	7	0.01
Carbon dioxide	0-30	3.6	0.01	10	0.02
Methane	0-35	0.2	0.01	3	0.01
Ammonia	0-2	0.7	N/M	0	N/M

Table 1: Typical process conditions and stream composition

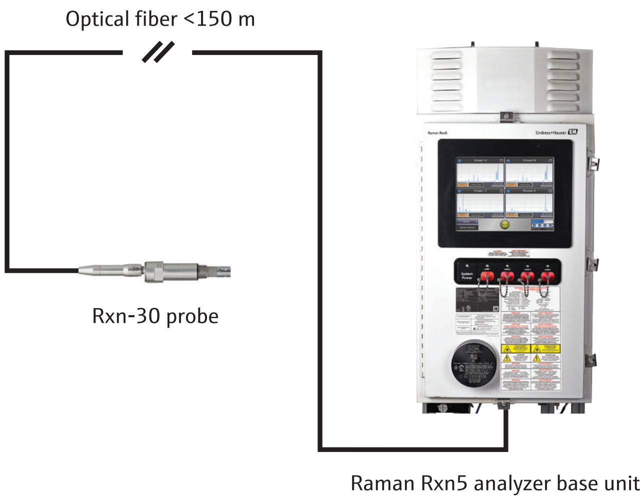

Figure 3: Recommended system configuration