Merchant hydrogen: HyCO production analytics overview

HyCO production and main uses Hydrogen is the simplest and most abundant element on earth. In 2013, the annual production of hydrogen was estimated to be about 55 million tons, with its consumption increasing by approximately 6% per year. Production is primarily from steam methane reforming (SMR) of natural gas and much of this hydrogen is used in petroleum refineries, in the production of ammonia for fertilizers, and in methanol production, as well as in food processing. Close to 50% of the global demand for hydrogen is produced via SMR of natural gas, about 30% from oil/naphtha reforming from refinery/chemical industrial off-gases, 18% from coal gasification, 3.9% from water electrolysis, and 0.1% from other sources.[1]

The overall HyCO production process A typical modern hydrogen-producing plant using natural gas as primary feedstock converts the natural gas in a steam methane reformer to syngas, which is a mixture primarily of H_2 and CO. The CO is then converted into additional H_2 and CO_2 in water gas shift reactors. When recovery and sequestration of CO_2 are required, further processing purifies the syngas by removing CO_2 via a CO_2 absorber. In many cases, CO_2 is purified and compressed, then transported via pipeline to oil producing areas where it is used for extended oil recovery (EOR). Often, H_2 is produced by third party bulk gas suppliers and transported via pipeline to H_2 consumers like refineries. In refineries, one of the most common uses of H_2 is in the various hydrotreater process units. Given its extensive use in refineries, recycle gas loops are commonly used to recover unused H_2.

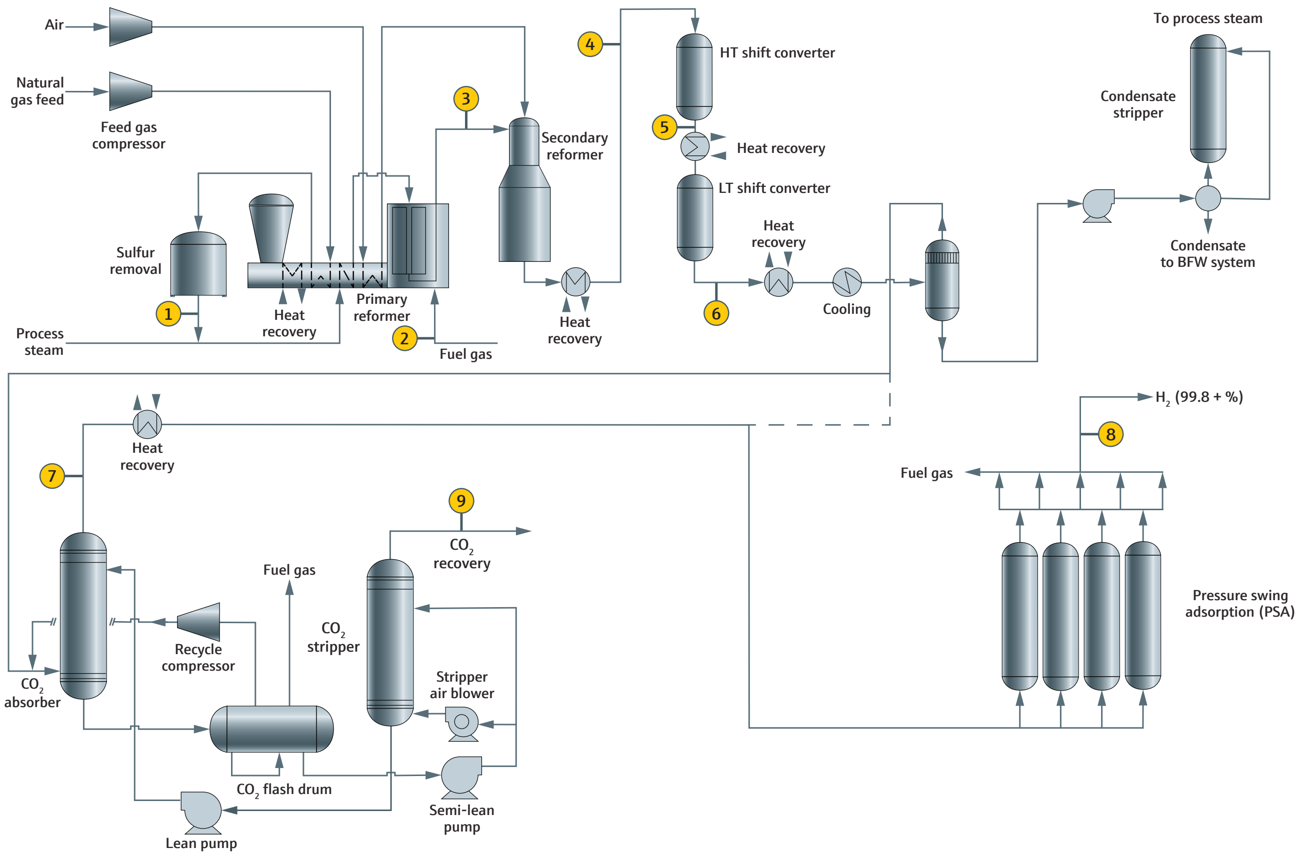

Figure 1: A simplified process diagram showing the main process units in a modern HyCO production plant using natural gas as the primary feedstock

Reference

1. Hydrogen Production Technologies: Current State and Future Developments, C.M. Kalamaras and A.M. Efstathiou, *Conferences Papers in Energy*, Vol 13 **(2013)**, Hindawi Publishing Corp., Article ID 690627.

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Process analytical challenges There are several streams that are typically analyzed in real time during the HyCO 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 gas chromatography, mass spectrometry, and photometry, in several cases steam content and the process conditions are severe enough to require special sample conditioning techniques. With these challenging samples, the ability to obtain reliable sampling and analysis is often compromised. The use of the Raman Rxn5 analyzer combined with a well-designed sample conditioning system is a robust solution for these challenging streams.

The Raman Rxn5 analyzer The Raman Rxn5 analyzer provides the unique spectroscopic ability to analyze the homonuclear 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. The Raman Rxn5 analyzer uses fiber optic cables of up to 150 meters in length to connect an Rxn-30 gas probe to the analyzer. The use of fiber optic cables allow the gas probe to be interfaced with a sample conditioning system near a sample tap point, so that no gas needs to be transported to the analyzer via expensive and high maintenance heated gas transfer lines. No potentially toxic or explosive gas mixtures are ever brought at or near the analyzer, eliminating the lag time associated with long sample transport runs. The safety of personnel is also enhanced because they do not need to come into contact with process gas to perform any routine maintenance on the analyzer. With a properly designed sample conditioning system, gas composition measurements can be made at temperatures up to 150 °C and pressures of up to 1000 psia. The ability of the Rxn-30 probe to measure under these conditions simplifies the sample conditioning required, and often allows the sample to be returned to the process after non-destructive Raman measurement, eliminating costly flaring.

	Stream service	Key measurement parameter	Pressure* (barg)	Temp* (°C)
❶	Merchant hydrogen: natural gas feed to primary reformer	Carbon number	26	25
❷	Merchant hydrogen: fuel gas to reformer furnaces	Btu	6	40
❸	Merchant hydrogen: raw syngas – primary reformer outlet	Composition/CH_4	36	800
❹	Merchant hydrogen: raw syngas – secondary reformer outlet	Composition/CO	35	370
❺	Merchant hydrogen: high temperature shift converter outlet	Composition/CO	34	445
❻	Merchant hydrogen: low temperature shift converter outlet	Composition/CO_2	32	220
❼	Merchant hydrogen: CO_2 absorber outlet – feed to PSA	Composition/CO_2	31	25
❽	Merchant hydrogen: PSA unit H_2 stream	Composition/H_2/N_2	18	30
❾	Merchant hydrogen: CO_2 absorber recovery stream	CH_4 impurities	5	30

Table 1: Summary of the typical streams analyzed on-line in a HyCO plant

* Pressure and temperature values listed are for typical process unit outlet streams