Refining

Hydrogen Plant is the sixth unit in this seven-step overview of Refining

Overview of Hydrogen Plant Process

The need for deeper hydrotreating, because of lower and lower sulfur levels in transportation fuels, and for the processing of heavier and higher sulfur crude slates is driving the demand for hydrogen. All hydrotreating processes to remove sulfur from the products require hydrogen. The major source of hydrogen in the refinery is normally the catalytic reformer off gas, which is rich in hydrogen. As sulfur removal increases though, most refiners find they need additional sources of hydrogen. Many refiners have either built an on-site hydrogen plant, or have a hydrogen plant on-site which is operated by one of the major commercial gas suppliers.

A hydrogen plant at a refinery often consists of a Steam Methane Reformer (SMR) and a hydrogen purification system, normally a PSA (Pressure Swing Adsorption) unit.

This process involves introducing preheated natural gas (or another hydrocarbon stream such as Refinery Off Gas) with steam across a catalyst to produce a 75–80% hydrogen stream composed primarily of hydrogen and carbon monoxide, then purifying this effluent, using either an MEA scrubber or a PSA unit, to produce 99%+ hydrogen.

Two reactions occur in the SMR:

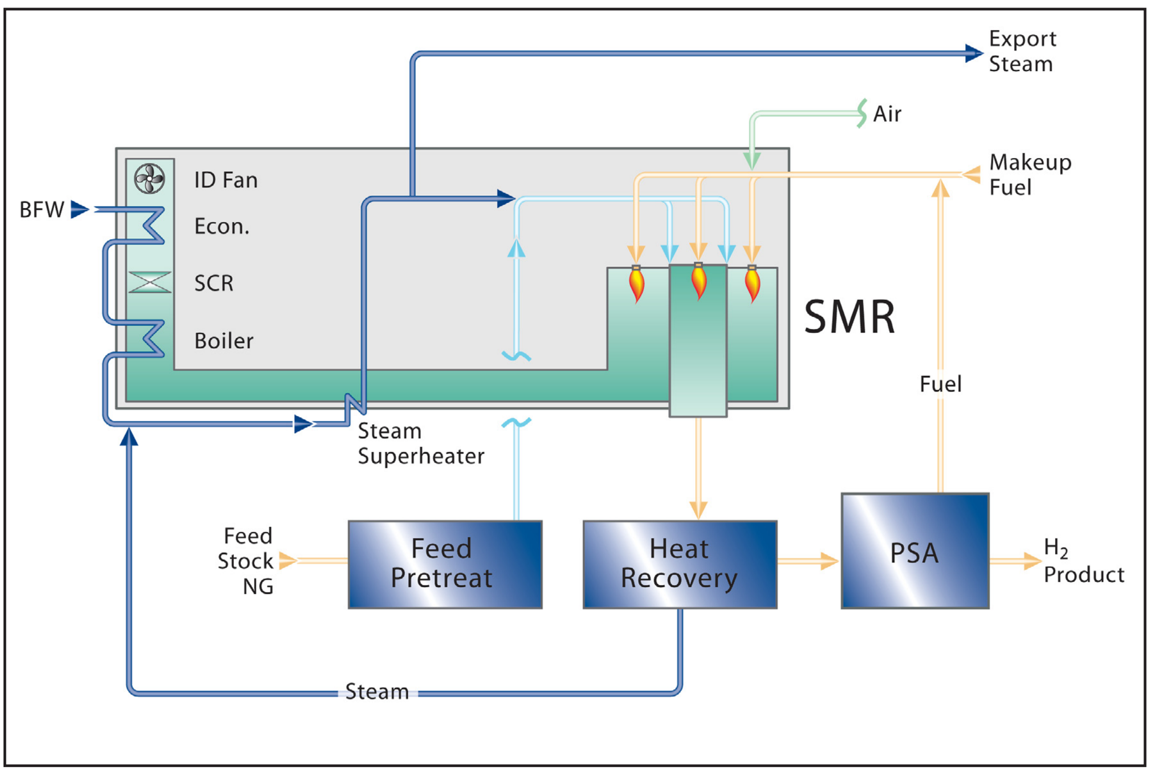
- First, the reforming reaction that converts hydrocarbon feedstock to carbon oxides and H_2

$$CnHm + nH_2O + heat \rightarrow n\,CO + (n/2 + n)\,H_2$$

- Second, the shift reaction that converts CO produced during the reforming reaction to carbon dioxide and additional H_2

$$CO + H_2O \rightarrow CO_2 + H_2 + heat$$

The second part of the process, hydrogen purification, is based on advanced pressure swing adsorption (PSA) technology. Polybed PSA units contain 4 to 14 adsorber vessels. One or more vessels are on the adsorption step while the others are in various stages of regeneration. Purified H_2 is delivered at essentially feed pressure. Purity can be 99.99mol%.



Hydrogen Plant Process Diagram

The challenges to the process are detailed on the next page.

Customer Challenges Overview

The hydrogen unit has become increasingly critical in order to be able to produce clean fuels, so reliability (availability) and throughput are the key issues. Decreasing maintenance and energy costs associated with the unit are also always important.

Customer Process Challenge #1 – Maintaining Steam-to-Carbon Ratio

Challenge: One of the key variables in operating the SMR unit is maintaining the proper steam to carbon ratio. Because in refineries the feedstock is typically a mixture of refinery fuel gas and natural gas, the composition is not constant. Maintaining the steam to carbon ratio is therefore a challenge.

If the steam to carbon ratio is run too low, carbon will deposit on the catalyst, lowering the activity of the catalyst. In extreme cases, the catalyst can be completely destroyed, and will need to be changed out, causing a disruption in the hydrogen supply. If the steam to carbon ratio is run too high, this wastes energy, increases steam consumption, and could also be affecting throughput.

Customer Process Challenge #2 – Increasing Efficiency and Lowering Maintenance Costs

Challenge: For the PSA section of the plant, the main issues are increasing efficiency and lowering maintenance costs. Leaking valves around the adsorption vessels is one of the biggest sources of problems and leads to a less efficient operation. Identifying where the leaks are occurring is the challenge.

Customer Process Challenge #3 – Controlling the Furnace

Challenge: With changing compositions of the fuel gas or fuel gas / natural gas supply, the energy to the furnace can fluctuate making it challenging to control the furnace efficiently. If the furnace uses a cascade control scheme of volumetric flow to temperature, and the composition of the fuel changes, a volumetric flow device will not see the change in the energy content, contributing to instability of the furnace.

Improving Blending Efficiency

Recommended Product Solution

Customer Challenge #1 - Steam-to-Carbon Ratio

Control Point Challenge: Improving control of the steam to carbon ratio for the SMR unit has an impact on the safety, catalyst life, and energy costs for operating this unit.

Solution: Micro Motion Coriolis meters can be installed on the fuel gas or natural gas feed to control the steam to carbon ratio. The mass of the gas is proportional to the carbon content, so the ratio can be calculated by assuming a constant carbon content per mass of the gas and controlling the steam flow accordingly. This is such a critical control variable that three meters are often used in parallel in order to utilize a 2 out of 3 voting scheme.

Competing Technology: Orifice dP meter and GC or mass spec for composition

Micro Motion ELITE CMF400, CMF400A, or CMF400E

Applications

- Fuel gas or natural gas to the SMR unit

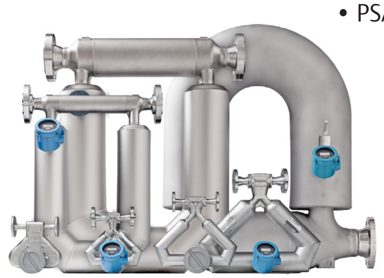
Customer Challenge #2 - Maintenance Costs

Control Point Challenge: One of the challenges of operating a PSA unit is increasing the efficiency and helping to identify leaks in the system.

Solution: Identify which valve and which adsorbent bed might be leaking by measuring the PSA flow in, and the H2 flow out. This will help to identify problems and troubleshoot the operation of the unit.

Competing Technology: Orifice dP meters

Micro Motion ELITE Family



Application

- PSA flow in, H2 flow out

Note: ELITE CMF meter size depends on plant capacity

Customer Challenge #3 - Controlling the Furnace

Control Point Challenge: Providing a steady amount of energy to the SMR furnace with variable composition fuel gas so that temperature can be closely controlled.

Solution: By using a Micro Motion Coriolis meter and measuring the fuel gas flow in mass instead of volume you are able to much better approximate the energy content going into the furnace. The Micro Motion Coriolis meter actually becomes a simple energy meter.

Competing Technology: Orifice dP meters

Micro Motion ELITE CMF200 or CMF300

Application

- Fuel gas to the Hydrogen furnace

EMERSON
Process Management

MC-00835