In focus...

Steam methane reformers

By Joanna Sampson

Although a relatively mature production process, steam methane reforming continues to be the leading, most common and economical way of producing hydrogen.

In the process, natural gas is mixed with steam heated to around 700 to 1,000°C which is then reacted with nickel catalyst to produce hydrogen, carbon monoxide and a small amount of carbon dioxide (CO_2) too.

The process of steam reforming was introduced to the industry more than 100 years ago. Today, the majority of globally produced synthesis gas, carbon monoxide and hydrogen are produced by steam reforming.

Technology

Air Liquide and McDermott are two companies that provide steam methane reformer (SMR) technology.

An SMR is a fired heater containing a combustion zone and a catalyst filled reformer tube which converts methane-rich hydrocarbon feedstock to synthesis gas, under the presence of steam across a nickel-based catalyst.

The furnace is where the process of liberating hydrogen from natural gas and steam begins. The gas and steam mixture travels down into reformer tubes that hang in vertical rows surrounded by gas burners that heat the mixture.

The reformer tubes are full of nickel catalyst, which triggers a reaction causing the methane in natural gas to react with water vapour to form hydrogen, carbon monoxide and carbon dioxide. Additional hydrogen is created in the water gas shift reactor. This is filled with an iron-chrome based catalyst that causes steam to break into oxygen and hydrogen. The hydrogen moves through the plant, while the oxygen joins carbon monoxide from the furnace and becomes carbon dioxide.

Over the last 12 months, Air Liquide, through its dedicated engineering and construction division, has constructed several SMRs all over the world, including:

- Constructing a steam reformer plant to produce methanol as an integral part of the Lurgi MegaMethanol™ process in the US, started up in mid-2018
- Providing steam reforming technology for a plant in the Middle East, which was successfully started up in mid-2018
- Delivering a tailor-made SMR for a world-scale hydrogen plant in Canada
- Constructing and starting a small-scale standard SMR plant for Air Liquide Argentina in Campana.

The Tier One company was awarded seven new projects containing SMR technology in 2018 with a total production capacity of 508,000 Nm^3/hr of hydrogen and 10,000 Nm^3/hr of carbon monoxide. Air Liquide Engineering & Construction is currently working on several SMR projects in different regions, with different capacities and applications, including:

- Small modularised standard hydrogen plants for hydrogen production, addressing the hydrogen mobility sector with a focus on hydrogen supplied to fuel stations in the US
- Tailor-made syngas production facilities for the chemical market in Europe
- World-scale hydrogen production facilities for major refinery projects in the Middle East and Asia.

Alexander Roesch, Director of the HYCO Product line at Air Liquide Engineering

& Construction, said Air Liquide has seen a continuation, and in some senses an acceleration, of the trend towards the energy transition over the last 12 months.

"Providers of energy are seeking to meet increased demand at an affordable cost, but with lower environmental impact and in particular through the development and deployment of lower-carbon technologies," he told **gas**world.

"For example, we are seeing increasing ambition in the use of hydrogen as fuel and as an energy carrier, with a range of piloting projects being undertaken in Europe, North America and Asia."

McDermott, which has designed and built over 200 hydrogen and syngas plants worldwide, confirmed it has been working on several SMR projects in North America, Europe, Middle East and Russia, and will continue to work on further projects in these regions over the next 12 months. In addition, there are multiple projects in various stages in India and the Far East.

Greg Shumake, McDermott's head of Hydrogen & Sulfur technology, said the technology, engineering, procurement, and construction firm has seen many changes in the market in the last 12 months. "Attractive economics for heavy crude processing, demand for higher octane gasoline, more stringent environment requirements, and emerging markets are driving demand for increased hydrogen production," he highlighted.

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Next generation

In what Roesch says is a "new milestone in SMR technology", Air Liquide is currently developing its latest technology advance – the SMR-X™.

The next generation technology focuses on increasing plant efficiency by producing hydrogen without excess steam.

"Compared with conventional steam methane reforming, SMR-X features higher thermal efficiency at low steam co-production ratios and emits lower levels of carbon dioxide – typically around 5% less," Roesch explained.

"The compact reformer design also results in lower capital expenditure and can be designed for maximum reliability and availability in operation."

After successfully demonstrating the technology, Air Liquide made an €80m investment in 2018 for the development of the first industrial SMR-X technology project, which will feed hydrogen into an Air Liquide hydrogen pipeline to supply a long-standing strategic customer in Belgium who is a leading supplier of high-tech polymer materials.

Trends

Air Liquide has been observing a greater degree of standardisation and the modularisation of a steam reformer plant for capacities of 10,000 to 50,000 Nm^3.

"We have played a significant role in influencing this trend and Air Liquide is proud to offer four standard sized technologies addressing this capacity range," said Roesch.

"These units have a compact layout and short project execution times, with lower capital expenditure. Different degrees of modularisation and standardisation can be applied to meet individual project requirements."

The French company is also seeing demand for an increased level of process flexibility for world-scale plants to deliver optimised performance.

"This includes having the capacity to use a wide range of feedstocks (such as natural gas, low-grade refinery offgas, liquefied petroleum gas or naphtha), the ability to integrate successfully with other process units, and the use of advanced control systems which enhance plant production reliability and availability," highlighted Roesch.

"These trends are enabling increased value creation by helping to manage increases in feedstock cost, integrate process solutions, and reduce CO_2 emissions."

For McDermott, Shumake said the company is seeing a global trend in reducing CO_2 emissions from SMR-based hydrogen plants. "Today, our clients are more focused on implementing higher efficiency SMR plants as well as reducing the overall CO_2 footprint of these units. The CO_2 reduction options typically include lower combustion requirements, removal of CO_2 from the syngas stream, removal of CO_2 from the flue gas, and the possible use of the CO_2 for enhanced oil recovery."

Increased refinery capacity

Both Air Liquide and McDermott highlighted an increased growth in hydrogen demand in the refinery sector.

"Areas of growth are in the Middle East, Far East, India and Africa where increased refinery capacity is needed and several new refineries and expansions have been announced," said Shumake.

"For Air Liquide, in addition to the traditional growth of hydrogen gas demand following global economic trends, we are anticipating growth in hydrogen demand in the refinery sector, particularly in the emerging market for upgrading diesel and gasoline," said Roesch.

Energy transition

As a co-founder of the Hydrogen Council – the first global initiative of its kind that aims to position hydrogen among the key solutions of the energy transition – Air Liquide is leading the development of the hydrogen economy in all its aspects.

"Hydrogen mobilisation, the use of hydrogen as an alternative feedstock for industry, or as an energy vector will create major opportunity for hydrogen production technologies such as steam methane reforming," enthused Roesch.

"To realise these ambitions, further technology development is required to revolutionise what is already a mature technology in order to enhance plant efficiency, reduce CO_2 emissions, support CO_2 capture and sequestration, and promote the use of renewable feedstocks such as biomethane."