Topsøe hydrogen technology – energy efficient and flexible solutions

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HALDOR TOPSØE

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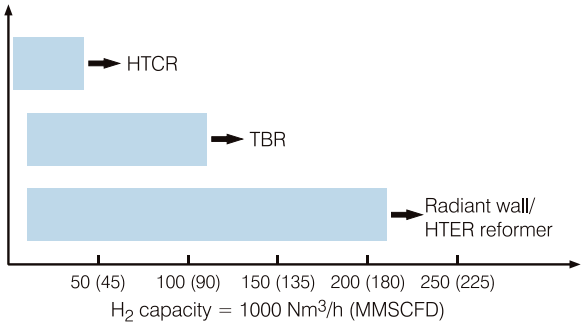
Topsøe hydrogen technology – processes for today and the future

Continuous development

Topsøe offers a range of innovative technologies for hydrogen production based on steam reforming of hydrocarbons. These technologies are continuously improved by integrating new catalysts and technology features – based on knowledge acquired from our in-house R&D as well as industrial experience with our catalysts and designs. Topsøe hydrogen technology is applicable for the design of new plants as well as for revamps.

Common features of Topsøe's hydrogen technologies are:

- high energy efficiency
- feedstock flexibility
- tailor-made and flexible design
- high on-stream availability
- safe and reliable operation
- minimum manpower requirements
- low maintenance costs
- low investment



Process steps

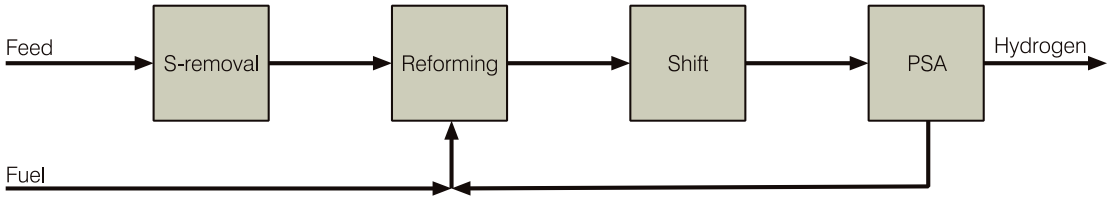
Feed purification
Feed purification effectively removes sulphur and chlorine compounds and saturates olefins, including di-olefins in the hydrocarbon feedstocks.

Prereforming
Prereforming is used for steam reforming of all higher hydrocarbons in the hydrogen plant feed resulting in stable and mild operating conditions for the steam reformer. Today more than 50 Topsøe hydrogen plants incorporate our prereformer design.

Steam reforming
The steam reforming process is the heart of the hydrogen production process and the right choice of technology is crucial for the overall plant economics. The use of Topsøe's reforming technology results in high energy efficiency and covers a wide range of capacities and client requirements.

CO conversion
The shift section is designed to maximise the hydrogen yield. The shift section consists of a high temperature shift reactor (HTS) or a medium temperature shift reactor (MTS), sometimes combined with a low temperature shift reactor (LTS).

Purification
Topsøe hydrogen technologies are based on hydrogen purification by a PSA unit optimised for maximum hydrogen yield and purity. Topsøe works with several PSA unit vendors.



Steam reforming technologies

Radiant wall steam reformer

The radiant wall steam reformer consists of a number of catalyst tubes in a single line in one or two fired boxes with burners placed at the walls at several elevations.

The burner flames are directed backwards against the furnace wall, eliminating any risk of flame impingement of the catalyst tubes. This burner arrangement enables full control of the temperature profile along the entire catalyst tube length. Therefore, the radiant wall steam reformer is able to operate at low steam to carbon ratios, unmatched high average heat fluxes, and at high outlet temperatures.

Topsøe's radiant wall steam reformer design has been in operation for more than 50 years and we have designed more than 250 units.

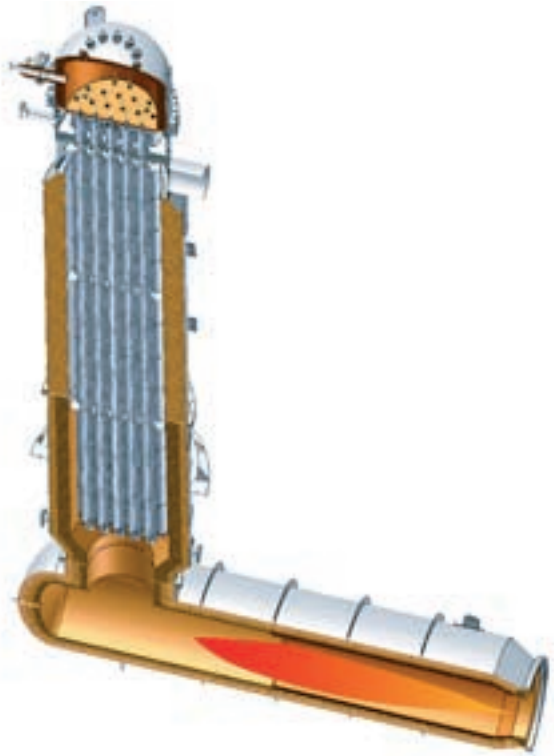
Haldor Topsøe Convection Reformer

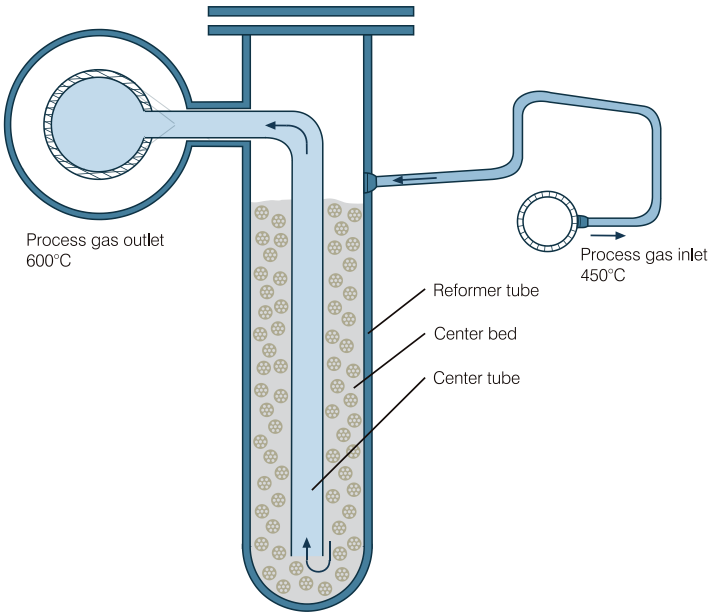
The Haldor Topsøe Convection Reformer (HTCR) is a heat exchange steam reformer in which the process gas is heated mainly by flue gas. An HTCR is very compact and suited for new hydrogen units and for revamps for capacity increase of existing plants.

The HTCR consists of a number of bayonet reformer tubes contained in a refractory-lined vessel. The heat from the flue gas is transferred to the process gas inside the bayonet reformer tubes resulting in low feedstock consumption and very importantly zero steam export.

An HTCR unit is to a high degree skid-mounted minimising erection time and cost on site. Topsøe can supply an HTCR unit including all equipment and materials within battery limits.

Industrial experience with HTCR includes more than 30 plants with capacities ranging from 5,000 to 30,000 Nm^3/h (4.5 to 27 MMSCFD).





Haldor Topsøe Exchange Reformer

The Haldor Topsøe Exchange Reformer (HTER) is a heat exchange steam reforming technology in which the reaction heat is provided by hot process gas. The HTER is used in hydrogen, ammonia and methanol plants in combination with a radiant wall steam reformer for additional capacity.

The HTER utilises a bayonet tube or a two-bed system allowing for optimal utilisation of the heat transfer areas. The hot steam reformer effluent is used as heating medium where the high pressure enables a very effective heat transfer.

The inclusion of an HTER unit reduces fuel consumption and steam production and may increase capacity up to 20-30%. Therefore, the HTER is well suited for both capacity revamps as well as new units where factors such as low steam export and compactness are important.

Since 2005 when the first HTER went into successful operation, the HTER technology has been adopted in several Topsøe designed hydrogen plants.

Topsøe Bayonet Reformer

The Topsøe Bayonet Reformer (TBR) combines the principle of convection heat transfer known from HTCR and radiant heat transfer known from the radiant wall steam reformer.

TBR provides hydrogen production with low hydrocarbon consumption and little or no steam export.

The TBR consists of bayonet reformer tubes in a furnace box heated by radiant wall burners. Improved heat utilisation in combination with a high average heat flux in the TBR tubes significantly reduces the size and capital cost of the hydrogen plant.

The combination of high energy efficiency and low steam export results in a uniquely low production of carbon dioxide per unit of hydrogen in the TBR.

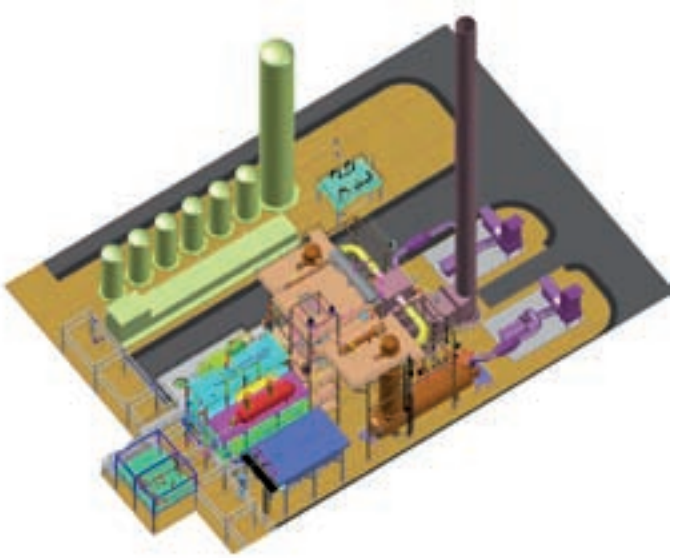
Revamp of existing hydrogen units

Revamping an existing hydrogen unit may be an economically attractive solution to increase capacity and decrease specific energy consumption. A revamp can also enable a plant to operate on additional types of feedstock.

Traditional debottlenecking may often give the desired result for a minor capacity increase (5-10%). When a significant capacity increase is desired (10-30%), installation of additional reformer capacity in the form of a heat exchange reformer (HTCR or HTER) operating in parallel or in series with the existing steam reformer is often an attractive solution.

The Methanol-to-Shift™ process is a revamp option suitable for peak-shaving applications based on methanol reforming over a Methanol-to-Shift™ catalyst. This option makes it possible to produce additional hydrogen at low capital cost.

In order to determine the feasibility of a revamp, Topsøe will perform a revamp feasibility study to provide the client with the optimal solution. The study will take into account the various requirements of the client as well as prevailing conditions such as availability and price of feedstock, plot plan, minimum downtime for revamp etc.



The Topsøe approach

Continued improvement

Extensive collaboration between Topsøe's engineering disciplines, Research and Development and industrial feedback ensures fast implementation of new ideas and design features for constant improvement of our technologies.

Topsøe's product portfolio includes catalysts, licensing of technologies, engineering of processing units, supply of hardware and technical services during the project and during the operation of the plant. Proprietary knowledge in these areas makes Topsøe a valuable business partner for our clients.

The Topsøe business portfolio

When working with Topsøe, you will benefit not only from our long-term involvement in the hydrogen industry but also from our broad scope of supply. In addition to our technology and catalysts for hydrogen production, Topsøe is also a leading supplier of innovative catalyst and technology solutions for hydroprocessing for the refining industry and for the production of ammonia, methanol, DME and synthesis gas for the petrochemical industry.

Environmental and safety aspects

Topsøe hydrogen plants are designed for minimum impact on the environment. The use of low NOx burners and full re-utilisation of process condensate is standard. Carbon dioxide emissions from Topsøe hydrogen plants are inherently low due to the high energy efficiency of the technology. Topsøe also offers solutions for carbon dioxide abatement and NOx reduction by selective catalytic reduction (SCR) for incorporation in the plant design to comply with any environmental requirements.

Topsøe hydrogen plants are designed to meet the highest international safety standards in all aspects of plant operation providing a safe and reliable plant.

Supply and services

For a hydrogen plant project Topsøe's scope of supply ranges from supply of license, basic engineering and catalyst to supply equipment and materials as well as advisory services during the entire project phase.

As after sales service, the Topsøe technical service team is ready to provide clients with professional advisory services to ensure safe, reliable and efficient plant operation. The Topsøe organisation includes a full range of engineering resources with access to Topsøe R&D and catalyst divisions to identify and solve even the most complex problems encountered.

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Corporate PR 06.2009.2

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