Topsøe HTCR
Compact hydrogen units

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Tube bundle with several bayonet tubes

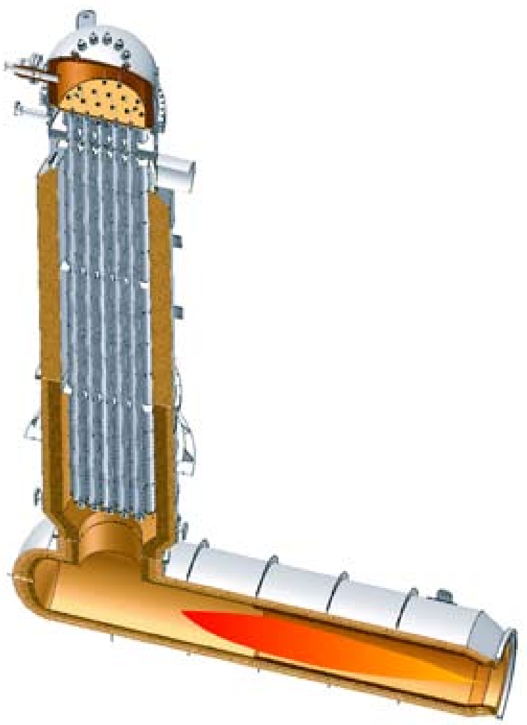

Figure 1: HTCR reformer layout

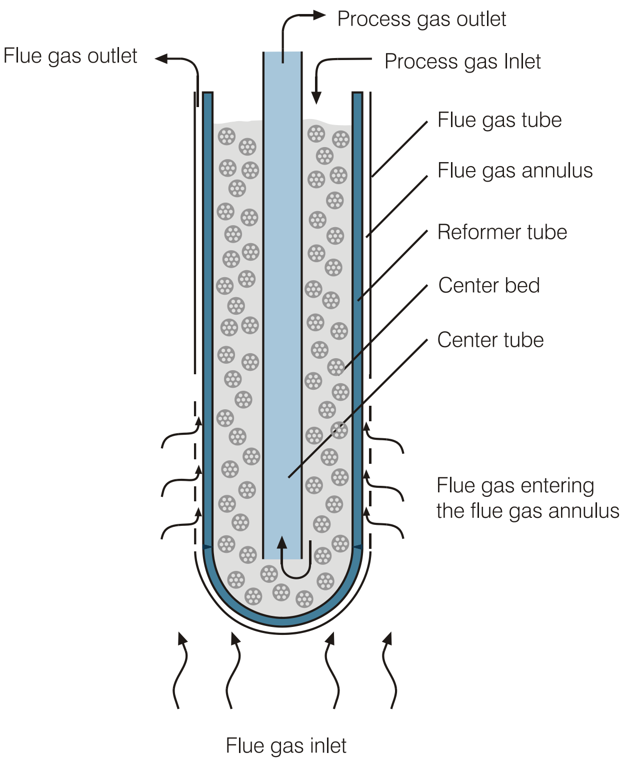

Figure 2: Principle of HTCR tube

Haldor Topsøe's hydrogen experience

Haldor Topsøe has designed more than 250 hydrogen plants with maximum capacity exceeding 200,000 Nm^3/h. For medium scale hydrogen production (5,000-30,000 Nm^3/h – 5-27 MMSCFD), Topsøe recommends a technology based on the Haldor Topsøe convection reformer (HTCR), which is a high efficiency, compact heat exchange reformer. The HTCR technology was developed in the 1980's and has been in large scale industrial operation since 1997.

HTCR design

The HTCR reactor is shown in figure 1 and the principle is shown in figure 2. The HTCR reactor consists of a vertical, refractory lined vessel, containing the tube bundle with several bayonet tubes. Each tube assembly is surrounded by a flue gas guiding tube, and the heat flux is adjusted by a proprietary flue gas control device. Below the vertical section is a horizontal combustion chamber containing the burner.

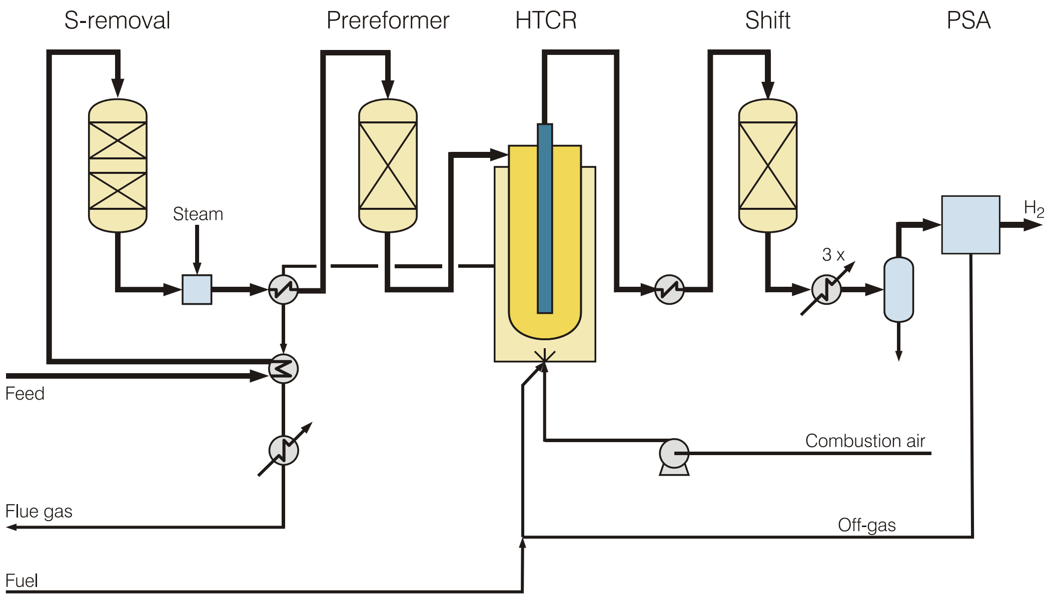

Figure 3: Typical layout of the HTCR process

The HTCR process

The HTCR process may use natural gas, LPG, naphtha or refinery off-gas as feedstock which is processed in the following steps:

- desulphurisation of feedstock
- prereforming in an adiabatic reactor
- convective reforming in a HTCR reactor
- shift conversion
- purification by Pressure Swing Adsorption (PSA)

The principle of the HTCR process is shown in figure 3.

A main characteristic of the HTCR is that it absorbs about 80% of the heat release of the burner into the process. This compares to about 50% in a traditional fired tubular reformer with radiant heat transfer. The main fuel for the burner is PSA off-gas and it is possible to balance the steam generation in the process which results in a plant without export of steam.

An HTCR plant is designed for automatic operation between 30 and 100% of rated capacity and is characterised by a very fast load response. The start-up, normal operation and shut-down is carried out by a PLC. Industrial experience has demonstrated that the process is very easy to operate and the requirements for supervision and maintenance are minimal. Actually there are examples of HTCR plants being operated unattended.

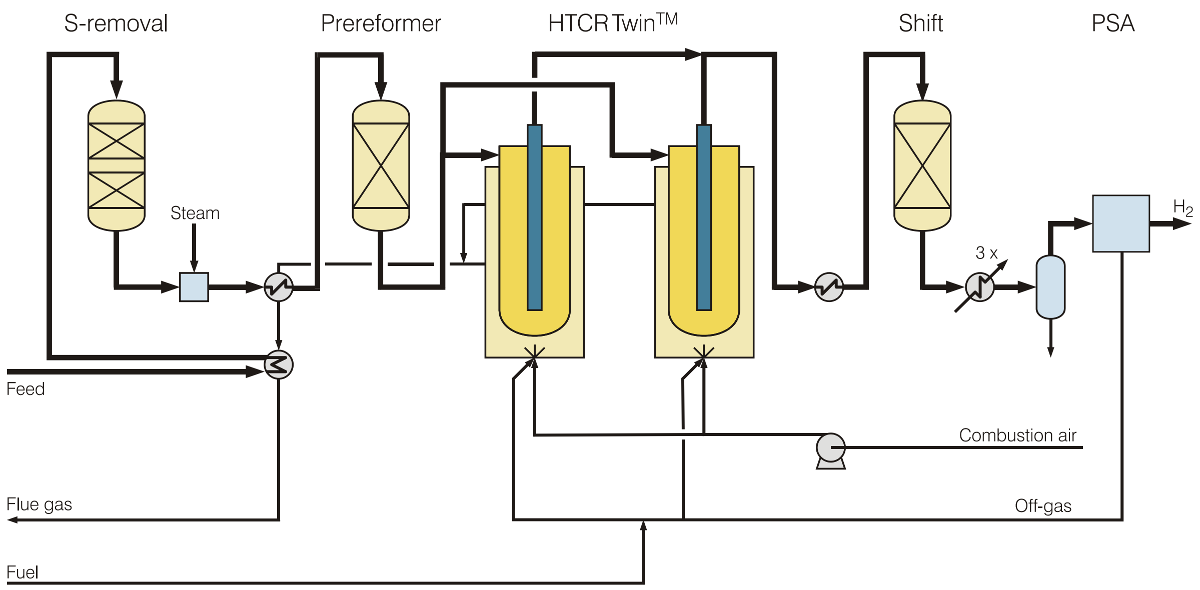

Figure 4: Typical layout of the HTCR Twin™ process

The HTCR Twin™ process

The HTCR Twin™ process allows for construction of plants with higher capacities using two HTCR units operating in tandem. A simplified process flow diagram is shown in figure 4.

The HTCR Twin™ process is ideal for capacities above 20,000 Nm³/h of hydrogen and depending on the plant configuration significantly higher capacities can be achieved.

The convection principle of an HTCR hydrogen plant leads to a low energy comsumption. Table 1 shows the typical consumption of feed and fuel in an HTCR plant compared with a traditional hydrogen plant.

It is clear that the performance of the HTCR based plant is quite attractive compared to the traditional process with a yearly cost saving of € 2.4 million (US $ 3.3 million) at a natural gas price of 25 €/Gcal (8 US $/MM BTU).

	HTCR proces	Traditional process
Feed, Gcal/1000 Nm³ H_2 (BTU/SCF)	3.32 (354)	3.30 (352)
Fuel, Gcal/1000 Nm³ H_2 (BTU/SCF)	0.1 (11)	0.50 (53)
Feed + fuel, Gcal/1000 Nm³ H_2 (BTU/SCF)	3.42 (365)	3.80 (405)
Cost of feed + fuel, MM €/year (MM US $/year)	21.8 (29.4)	24.2 (32.7)

Table 1: Energy consumption and cost for 30,000 Nm³/h hydrogen

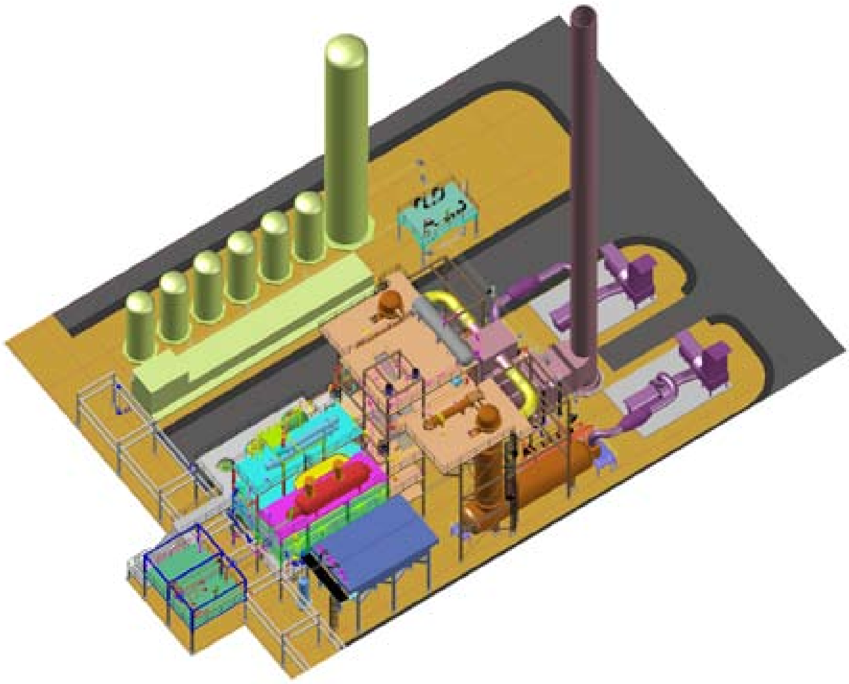

Figure 5: 3D arrangement of an HTCR Plant

Plot plan area

The convection principle allows for the design of compact reformers, and an HTCR hydrogen plant can be supplied as a very compact unit with part of the equipment supplied skid mounted. Typical plot plan area for a 30,000 Nm^3/h (27 MMSCFD) plant is 50 x 40 m (164″ x 131″) and can be adjusted according to conditions at the client's site. The required plot plan area for an HTCR unit is approximately 30% less than a conventional hydrogen unit with a box type reformer (SMR). Figure 3 shows the plant layout for a 30,000 Nm^3/h (27 MMSCFD) HTCR plant.

Scope of supply

In connection with HTCR hydrogen plant projects, Haldor Topsøe's typical scope of supply is

- license
- basic engineering
- full plant documentation
- supply of all materials and equipment within battery limits
- on-site supervision (of assembly, precommissioning, start-up, test run)
- training of operators

Workshop skid assembly

Due to the compact layout, a large part of an HTCR plant can be preassembled in skids in a workshop outside a client's plant site. Depending on plant capacity, the skids are assembled in the workshop with vessels, heat exchangers, reactors, valves, instrumentation, piping etc.

For transport reasons the skids are separated by cutting the interconnecting piping.

Site installation

The use of preassembled skids minimises installation time and erection costs compared to a traditional plant. Typically, the site installation can be completed in three months and where the site installation work for a traditional steam reformer plant often amounts to 30-35% of the investment cost, an estimate of only 15-20% can be applied for a skid mounted HTCR unit.

The catalysts

The different types of catalysts used in the HTCR hydrogen plant are state-of-the-art catalysts developed and produced in-house by Topsøe.

The catalysts are used in hundreds of process plants worldwide and will ensure an outstanding performance with respect to operation and lifetime

Safety

The HTCR hydrogen plants are designed according to the highest safety standards without compromising the overall efficiency and reliability.

Advantages of HTCR and HTCR Twin™ processes

- low investment and more hydrogen produced per unit of feedstock consumed leading to substantially lower operating costs
- a very compact skid-mounted design – an HTCR is to a large extent supplied as a preassembled plant minimising erection time and erection costs
- a well-proven and safe concept that ensures low manpower requirements, easy operation and a fast load response of the HTCR plant

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