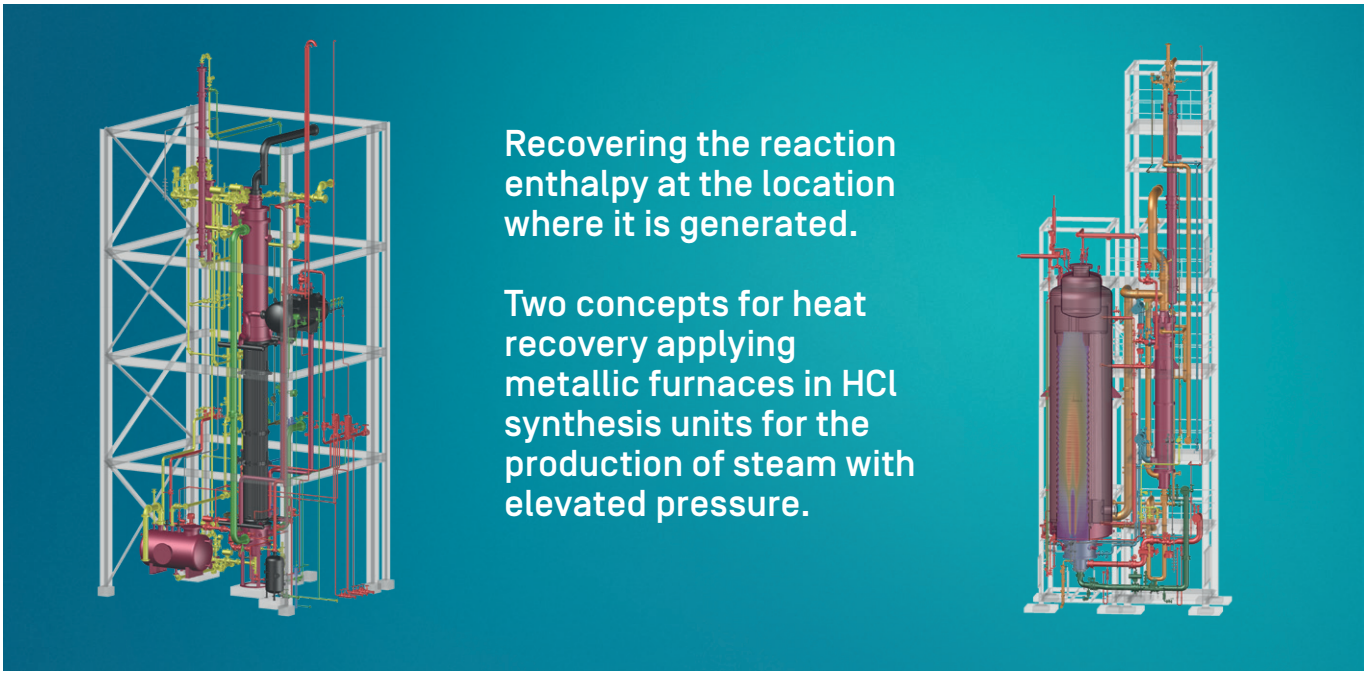
sgl carbon

Heat recovery in HCl synthesis units

Process Technology – White paper



↑ Layout sketches for synthesis units with membrane wall reactor (left) and ECOSYN® (right)

The need for sustainable solutions to minimize CO_2 emissions and the impact of increasing fuel prices that affect operation costs, boost the demand for energy efficient processes. The reaction of chlorine and hydrogen is carried out in HCl synthesis units at elevated temperatures, providing a significant amount of recoverable energy.

While it is still common to remove the waste heat using cooling water, more and more end-users are considering HCl synthesis units with steam generation systems. In this white paper we would like to give an overview on two furnace concepts to recover heat as valuable steam.

Although it is possible with minor modifications to design graphite furnaces for the energy recovery by hot water, it was not until the 1990's that the first synthesis units were equipped with metallic furnaces for generating valuable high-pressure steam.

Since then, synthesis units with such furnaces have been applied in the mining, polysilicon and chlor-alkali industries, providing significant advantages by lowering operating expenses. The generated steam is commonly used in caustic concentrators in which the elevated pressure is of particular value.

Furnace design

Efficient heat recovery systems focus on processing the HCl gas close to the adiabatic flame temperature of 2500 °C. Compared to graphite furnaces, metallic furnaces can be built with minimum wall thicknesses for applications with high steam pressure. By providing sufficient heat exchange area, such metallic furnaces are operated at rather moderate surface temperatures and thermal stresses, even for applications with high capacity.

This allows the placement of the heat recovery device at the location of the peak reaction temperature, resulting in maximum recovery rates, without the risk of material damage. Another advantage of this arrangement is that the high heat recovery rate is also given at turn-down capacity. Furthermore, such furnaces allow the generation of valuable steam with a pressure of 10-12 barg. Proven concepts have been developed to prevent the condensation of the minor moisture content in the process gas that could cause corrosion of the steel surfaces. The furnace design in SGL Carbon's synthesis units with steam generation includes our reliable burner tube design that allows fast and easy replacement of the tubes.

Concept 1: Membrane wall reactor

The membrane wall reactor is designed as closely as possible to the standard bottom-fired synthesis unit, combining their advantages, but with higher efficiency considering cooling water demand and steam production. Accordingly, the graphite furnace is replaced by a metallic design.

The functionality on the process side remains unchanged, which leads to a compact unit, keeping the proven safety concept including the direct connection of the furnace to the rupture disc. The steam is generated in finned tubes operated in a thermosiphon loop, which is connected to an external steam drum.

This concept does not require hot water circulation pumps which impact operation cost and system reliability.
The absorber is mounted directly on top of the furnace avoiding additional piping and bellows for transferring the hot HCl gas. The proven absorber design does not require an acid recycle and typically discharges the product acid with sufficient static height to the pipe rack or a storage vessel without transfer pumps.
For customers that require HCl gas instead of hydrochloric acid, the unit is supplied with a gas cooler rather than an absorption section. The robust design allows the operation of the unit at elevated pressures of up to 3 barg on the process side.

Concept 2: ECOSYN®

The ECOSYN synthesis unit is the 2nd generation of steam systems with improved efficiency, enhanced steam pressure and minimal risk of corrosion due to acid condensation. The ECOSYN combines the furnace and steam drum avoiding interconnecting steam piping and also the hot water circulation pumps. The conversion of chlorine and hydrogen is carried out in a flame tube and is subsequently processed in a tube register.

This allows a more complete recovery of the reaction enthalpy from the adiabatic flame temperature of 2500 °C down to 250 °C. The use of a metallic furnace in the steam boiler avoids surface temperatures on the process side below the dew point of the hydrochloric acid, thus avoiding corrosion.
The ECOSYN system provides the highest energy recovery rate in the market while generating high pressure steam at the same time.

Product quality

Applying our proven burner design concepts as used for standard graphite units even while increasing the furnace size and residence time for the reaction, results in extraordinarily low chlorine contents in the product acid while operating with low hydrogen excess.

The application of the above-mentioned metallic furnaces will lead to minor impurities of iron in the product acid of approx. 1 ppmw. Concepts are available to prevent iron contamination by either applying a coating on the steel parts or installing an ion-exchanger for the product acid.

Comparison membrane wall reactor and ECOSYN®

Design criteria	Membrane wall reactor	ECOSYN
steam generation	0,6 t of steam per 1 t of chlorine	0,9 t of steam per 1 t of chlorine
steam pressure	10 barg	12 barg
product	hydrochloric acid / HCl gas (3 barg)	hydrochloric acid / HCl gas (0,3 barg)
absorber/steam drum	integrated/external	external/integrated

Process Technology | SGL CARBON GmbH
Sales Europe/Middle East/Africa | pt-europe@sglcarbon.com
Sales Americas | pt-americas@sglcarbon.com
Sales Asia/Pacific | pt-asia@sglcarbon.com
www.sglprocesstechnology.com

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