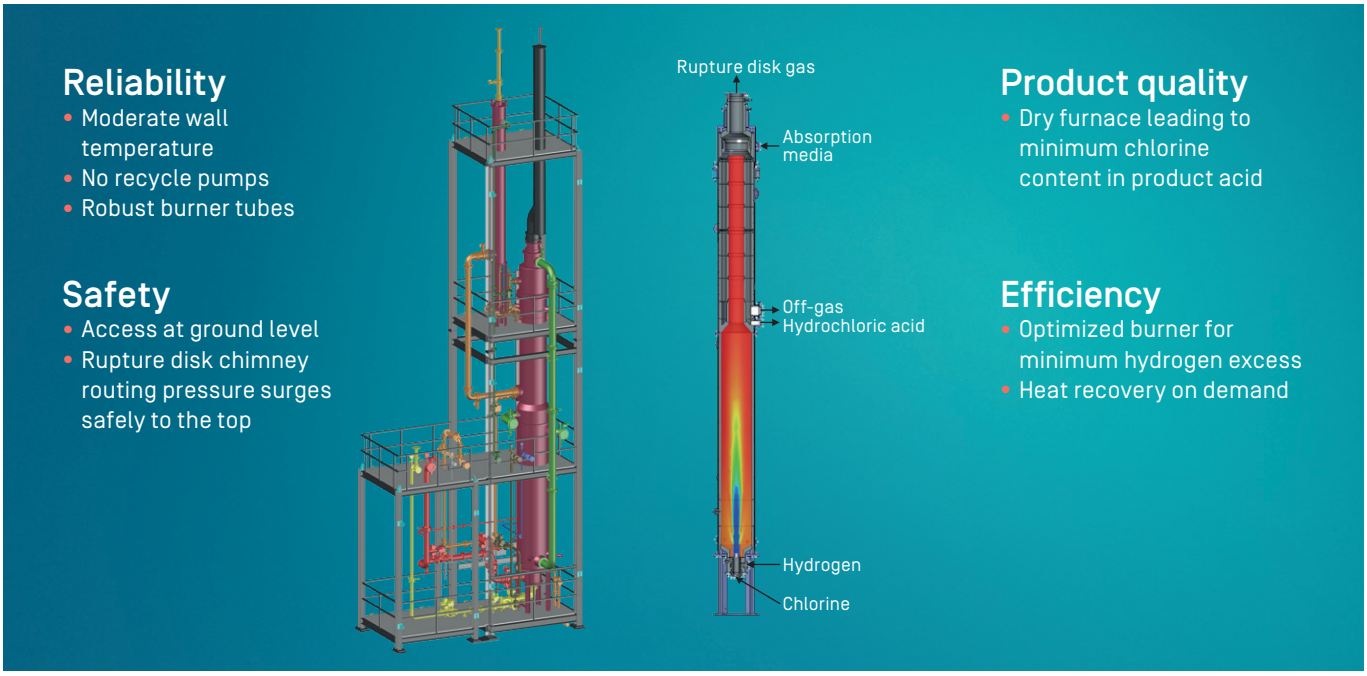
sgl carbon

Bottom fired HCl synthesis units

Process Technology – White paper



↑ Flow and layout sketch for bottom fired synthesis

The synthesis of hydrochloric acid by conversion of chlorine with hydrogen is typically carried out in graphite equipment since it provides excellent corrosion resistance and thermal conductivity.

The high thermal conductivity not only is required for removal of the excessive amount of heat generated but also to ensure a low material wall temperature of the strongly exothermal reaction carried out at a temperature above 2000 °C.

Equipment in which this process is carried out, typically named HCl synthesis units, have been developed and improved over decades resulting in highly sophisticated systems to ensure maximum safety and reliability.

Hydrochloric acid produced in HCl synthesis units in contrast to many other process routes typically reaches the highest product quality. In this white paper, we would like to focus on the distinctive features of our most common system, the bottom fired HCl synthesis unit.

Equipment description

Our bottom fired HCl synthesis unit consists of a graphite furnace inside of which the conversion of the feed streams is carried out. A falling-film absorber is placed at the top of the furnace connected via a cooled gas channel. In the absorber strong hydrochloric acid is produced by isothermal absorption of the HCl gas in water. Since a hydrogen excess is used to ensure the complete reaction of chlorine, HCl-containing off gas streams need to be processed in a subsequent vent gas scrubber that may be integrated into the synthesis unit (type i) leading to most compact equipment and avoiding interconnecting piping or installed as separate equipment (type e).

Process challenges

The challenges of the process are mainly due to the compounds involved, which are toxic and oxidizing (hydrogen chloride, chlorine), ultra-corrosive (hydrochloric acid) and can form explosive mixtures. The reaction enthalpy generates extreme temperatures of up to 2500 °C resulting in an additional challenge for the material. Furthermore, environmentally hazardous off-gases need to be processed.

Safety concept

The safety concept of our bottom fired units is based on risk assessments and operational experience from a multitude of projects for various applications executed in the past decades. Applying high-grade DIABON® graphite that is comprehensively jacketed in a steel shell minimizes the risk of exposure to process media. Placing the furnace at ground level not only makes the accessibility convenient, but also ensures short rescue paths. The core device for monitoring all safety functions during operation, start-up and shut-down is our safety system. The fully automated start-up sequence safely establishes the pilot flame which subsequently initiates the main hydrogen chloride flame while continuously monitoring all critical process parameters. The fact that high density chlorine gas remains in the bottom of the unit and that the main flame cannot be established if the pilot flame malfunctions minimize the risk of chlorine exposure when an interruption of the start-up sequence is necessary. A key safety measure incorporated into our bottom fired unit is the direct connection of the combustion chamber to the graphite rupture disc. If a pressure surge occurs, process gases are quickly released at the top avoiding harmful overpressure resulting from bottlenecks inside of the unit. Our qualified engineers design the synthesis unit specifically for your process conditions respecting thermal impacts of side reactions, consult during HAZOP studies, conduct trainings, and support the start-up and service of our units.

Efficiency

A considerable amount of energy is generated in HCl synthesis units. Please see our white paper on energy recovery in synthesis units or contact us for additional information.

Reliability

Unscheduled down times due to service, equipment repair and spare part lead times may cause significant production losses. Therefore, our philosophy is to generate value by offering a reliable design to minimize down-times.
To face extreme process conditions, our robust design includes a water cooled, jacketed furnace with sufficient heat transfer area to cool down the process gases to moderate temperature levels, minimizing the risk of material failures by thermal stress. Spacious cooling water slots operated at a low surface wall temperature are less sensitive to fouling and minimize the risk of overheating the graphite parts.
The moderate temperature levels also allow the application of our fully corrosion resistant pilot burner made of PTFE and an efficient impervious graphite isothermal absorber. The absorber is equipped with inlet crowns to establish a homogeneous falling film and does not require an acid recycle, which avoids possible shut-downs due to pump failure. Since the absorber is located at the top of the furnace, the acid can typically be routed without transfer pumps to the pipe rack or storage tank. Additionally, our patented burner tubes are designed to withstand unfavorable feed gas conditions containing mist or saline entrainment. The robustness of our graphite burner tubes is enhanced by our unique burner flushing concept, which effectively removes deposits during operation, reducing downtimes for cleaning. The simple sealing concept allows the burner tube exchange in typically less than two hours. Burner tube fragments can be easily removed at the furnace bottom.

Product quality

For optimum product acid quality, a complete conversion of the reactants needs to be ensured. This leads to a hydrochloric acid product with minimum chlorine content while using minimum hydrogen excess. To minimize transport costs, high acid concentrations are favored.
The concept of applying large and robust furnaces is also beneficial for reaching complete conversion of chlorine by providing sufficient reaction time. As no rinsing film is required for cooling the furnace, absorption of non-reacted chlorine at the combustion walls is avoided, leading to a product acid with extremely low chlorine content.
Our vent gas scrubbers are designed using state-of-the-art process simulation tools. Sufficient flexibility to cover deviations caused by measuring accuracy and process fluctuations are included in the design to ensure the quality of the clean vent gas.

Total cost of ownership (TCO)

Maximum revenue resulting from excellent product quality and highest uptimes with minimum operational expenditure based on utility use (pump duty, hydrogen excess) and maintenance requirement (burner tube, rupture disc, instrument consumables) result in lowest TCO for which the unit is designed for.

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