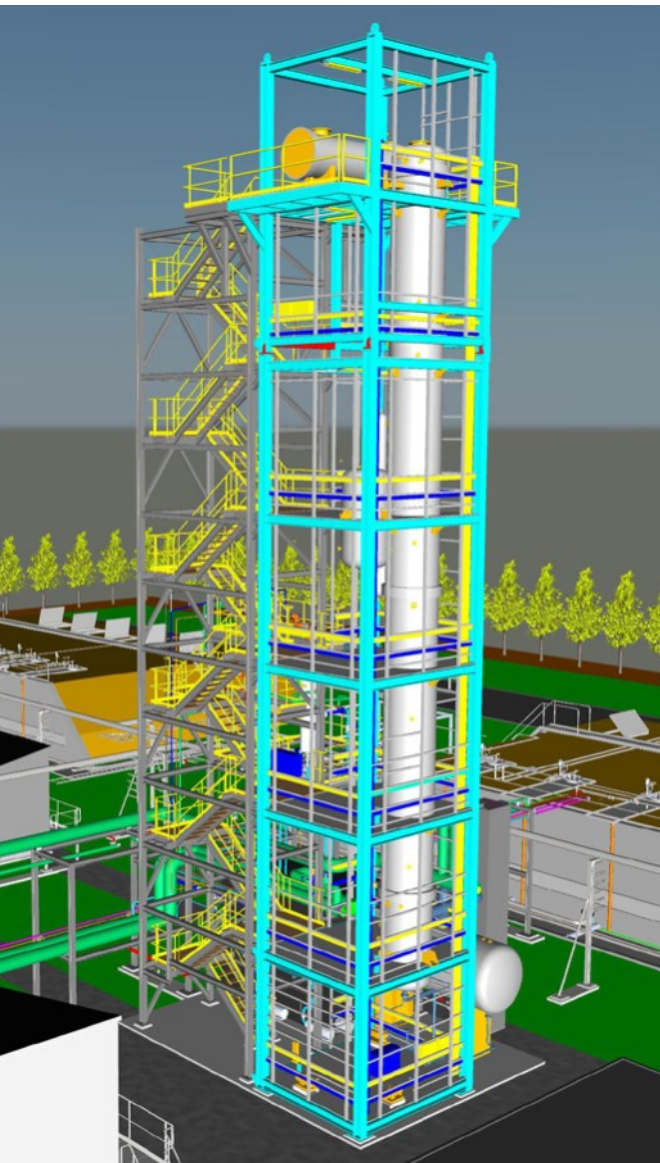


SULZER

Process plants



Process plants at Sulzer Chemtech

Sulzer Chemtech, a member of the Sulzer Corporation, with headquarters in Winterthur, Switzerland, is active in the field of process engineering, employing 3'000 persons worldwide. Sulzer Chemtech is represented in all important industrial countries setting standards in the fields of mass transfer and static mixing with its advanced and economical solutions.

Sulzer Chemtech is organized into four business units, one of which is the process technology group. This business unit was formed in early 2009 following the acquisition of Kühni, a Swiss company with more than 75 years experience in innovative separation processes. Today, Sulzer Chemtech process technology is headquartered in Allschwil (Basel), Switzerland.

By combining Sulzer's and former Kühni's proven process technologies and expertise, Sulzer Chemtech Process Technology is now uniquely positioned to offer process solutions for demanding, industrial separations based on an excellent portfolio of the following unit operations:

- Distillation, absorption and reactive distillation
- Film evaporation
- Liquid-liquid extraction
- Crystallization
- Membrane separation

In addition, Sulzer Chemtech has extensive experience and know-how in providing process solutions for a wide range of process applications such as:

- Solvent recovery
- Product purification
- Wastewater and vent gas treatment
- Food and beverage
- Biofuels and biochemicals
- Reaction technology
- Polymer production, including polystyrene (PS), expandable polystyrene (EPS) and poly lactic acid (PLA) production

This establishes our active position in the following industry segments:

- Fine and specialty chemical industry
- Chemical and petrochemical industry
- Pharmaceutical industry
- Polymer production industry
- Food and beverage industry
- Biofuels and biorefinery industry

Our services and sales activities are organized globally, with the support of representatives in all key countries of Europe, Asia and the Americas. This way we are close to our customers.

One of our core strengths is that the entire project scope is provided from a single point of responsibility. Our activities cover the full project development cycle from the initial conceptual design and testing up to start-up of complete plant solutions. We offer:

- Testing and sample production services, provided by state-of-the-art laboratory and pilot test centers
- Engineering services including feasibility studies, plant optimization, revamp and debottlenecking studies, and conceptual designs

- Basic and detail engineering packages
- Fabrication and supply of proprietary and key process equipment
- Fabrication and supply of complete process plants as modular units
- Project management, installation, commissioning, start-up and after sales services

We have a proven track record in developing innovative solutions to complex separation problems, where our unique and extensive experience in combining process unit operations from our wide portfolio into hybrid plant solutions is paramount. This, together with our capabilities to supply state-of-the-art process equipment and complete plant solutions are key to our success.

We are a reliable innovation partner and preferred supplier for our customers globally. We deliver our solutions with guaranteed performance.

Unit operations – Distillation, absorption & reactive distillation

Sulzer Chemtech has a long-standing experience in distillation and adsorption, with innovative solutions such as reactive distillation

Distillation and absorption

Distillation is the most commonly applied separation technology. Sulzer Chemtech has been supplying process solutions in this field since 1940. To date more than 100'000 columns are operating with Sulzer equipment, in over 500 different applications.



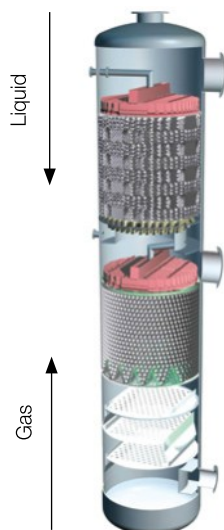
- Structured packing (like MellapakPlus™ and BXPlus™ gauze packing)
- Random packing
- Trays (conventional, high performance and cartridge trays)
- Column internals (like distributors and collectors)
- Vapor-liquid and liquid-liquid phase separators (like KnitMesh™ mist eliminators and Mellachevron™ vane packs)

The design of distillation units is geared to deliver an improved product quality, increased capacity and reduced energy consumption. Design activities are supported by computer simulations and in-house pilot plant testing. Our vast experience and know-how in the field of distillation combined with a profound understanding of column hardware ensures we offer the optimum solution

Sulzer Chemtech is a leading expert and solutions provider for a range of distillation technologies:

- Continuous and batch distillation
- Single- and multi-stage distillation
- Extractive distillation
- Azeotropic distillation
- Pressure swing distillation
- Reactive distillation
- Divided wall columns

Our product portfolio includes a unique and complete range of the best performing, state-of-the-art column internals:



Distillation column sketch with different internals

to our clients. We offer customers either a basic engineering package including key equipment (column shells, internals, heat exchangers and decanters), or a complete, often skid-mounted unit including process control and start-up support services.

Reactive distillation

Reactive distillation is a state-of-the-art development combining distillation and chemical reaction in one single operating unit. This technology is highly valuable for equilibrium-limited reactions, such as esterification. The level of conversion is increased by continuously removing the reaction products from the reaction zone via distillation.

In general, reactive distillation units feature:

- Fewer distillation columns
- No or smaller recycle streams
- Utilization of heat of reaction for mass transfer
- Higher product yields
- Lower capital investment
- Lower energy costs



Installation of a slit tray

Unit operations – Film evaporation

Sulzer Chemtech's film evaporation technology produces high-purity substances from heat sensitive and complex products

Vacuum conditions and a short contact time of the product with a heated surface are two essential parameters to prevent secondary reactions (like polymerization and condensation) and to preserve organoleptic properties (color, smell, taste), as required in many industries - food, fine chemical, pharmaceutical. These parameters are incorporated in our film evaporation technologies.



Falling film evaporator

Falling film evaporator

The tubular falling film evaporator is specifically suited for processing temperature sensitive products with a low viscosity and tendency for fouling. It consists of a tube bundle crowned by a proprietary liquid distribution device, which ensures an efficient and uniform distribution of the liquid to all the tubes, as well as a continuous film along the tube length.



Rotor of a wiped film evaporator

Usually the liquid and resulting vapors flow co-currently from the top to the bottom and a gas-liquid separator is applied to separate the exhaust streams. This separator is not required in counter-current applications (stripping) or when the falling film evaporator is used as a reboiler of a distillation column.

Thin or wiped film evaporator

The thin or wiped film evaporator is the ideal apparatus for continuous processing of heat sensitive, viscous and/or fouling products. It consists of a single evaporation tube fitted with a mechanical rotating device that ensures a uniform distribution of the liquid on the heated surface, a constant mixing of the film and minimal fouling of the evaporation surface.

The vapors produced rise upwards, counter-currently to the liquid and, when required, pass through a mist eliminator mounted in the top section. Thanks to the large cross-sectional area, the pressure drop across the evaporator is low (typically less than 0.05 mbar) and operation in the vacuum range as low as 0.5 mbar is possible.

Short path evaporator

In the short path evaporator, a vertical condenser is placed inside the wiped evaporation chamber. This results in a very short distance between the heating and condensing surface. The pressure drop across the system is thus minimized and evaporation in the pressure range below 1 mbar is feasible. Due to the short residence time, highly temperature sensitive substances and compounds with high molecular weight can be purified at high purities and yields.

Typical applications

Sulzer Chemtech's falling and thin film evaporators are widely used in the organic chemical industry, as column reboilers in (high) vacuum distillation systems. Other typical applications are:

- Product purification
- Solvent recovery
- Concentration of solutions and slurries
- Crystallization
- Drying
- Treatment of industrial waste streams



Test rig for a wiped film evaporator

Unit operations — Liquid-liquid extraction

Sulzer Chemtech's liquid-liquid extraction is a technically sophisticated separation technology, offering a solution where other technologies are uneconomical or not suitable

Liquid-liquid extraction is a complex separation process in which the components are extracted from the feed stream with the help of an extractant, or solvent. The components to be extracted have a different solubility in the two immiscible, or partially miscible, liquids. Both liquids have to be thoroughly contacted and subsequently separated. The liquids flow counter-currently and the required purity and yield determines the number of separation stages.

In the field of liquid-liquid extraction, Sulzer Chemtech's range of equipment covers many industrial applications and is based on a number of modern, efficient types of extractors.



Kühni agitated column internals

Column type extractors

Kühni agitated column (ECR)

In applications with high mass transfer and/or changing physical properties, this is the column of choice. The compartment geometry can be adapted to compensate for changing conditions resulting in a constant high column performance. The main features are the special mixing turbines and the perforated partition plates.

Packed column (ECP)

The key benefit of a packed column is the high throughput which leads to small column diameters. Together with specially adapted liquid distributors, our structured packing provides the best extraction performance.

Mixer-settler type extractors

Mixer-settlers, both as stand-alone and as in-column type, are offered for special applications:

Mixer-settler (EMS)

Due to the pump-mix turbine no additional feed pumps are required in most cases.

Kühni mixer-settler-column (ECMS)

This special type of equipment combines the stage-wise operation of mixer-settlers with the small footprint of a column.

Typical applications are:

- Recovery of carboxylic acids, for example, acetic acid
- Extraction of aromatics, for example, from oil
- Washing of organic solvents
- Cleaning of aqueous effluents from high boiling impurities like phenol



Liquid-liquid extraction packing

- Wet purification of phosphoric acid (food grade)
- Recovery and purification of active pharmaceutical ingredients (API's)
- Solvent de-asphalting
- Solvent recovery

Sulzer Chemtech is a market leader with extensive experience in these applications. Our broad know-how covers selection of the most suitable solvent and optimum equipment selection and design. Equipment design is backed-up by elaborate research by universities. Furthermore, testing activities provide a solid basis for reliable designs and scale-up procedures, and a complete range of test equipment is available in our in-house test center. This way, even in difficult cases, the optimum process solution is achieved.



Unit operations — Crystallization

Sulzer Chemtech's crystallization technology is solvent-free and has proven to be a most reliable and environmentally friendly separation technology

Sulzer Chemtech is the leading supplier of technology, proprietary equipment and engineering services for fractional crystallization. Crystallization is often the best alternative when distillation is difficult, or even impossible. High purity products are manufactured from close boiling or azeotropic mixtures or components that are thermally unstable at their boiling point. The technology has proven to be the most reliable and environmentally friendly crystallization process, because crystals grow directly from the melt without the use of solvents. Selection of the most suitable technology is supported by bench and pilot scale testing. Typical applications are the purification of:

- Monomers
- Carboxylic acids
- Tar chemicals
- Waxes
- Organic and inorganic chemicals at high purities

Static crystallization

The Sulzer Chemtech static crystallizer is equipped with vertical plates immersed in a stagnant melt. Crystal layers grow on the cooled plates. Following crystallization, the remaining impure melt is drained from the crystal layer, which then is further purified by sweating. Hereafter, the purified product is recovered by melting the crystal layer. Sweating and melting is established by heating the plates.



Static crystallizers for paraffin deoiling

Falling film crystallization

The falling film crystallizer contains vertical tubes through which the melt flows as a falling film. The crystal layers grow in the form of cylindrical shells inside the cooled tubes. Crystallization is followed by sweating and subsequent melting of the product. A high thermal gradient can be imposed and crystal growth rates are fast.

Suspension crystallization

Chemtech's suspension crystallization is an advanced, highly selective, energy efficient separation process. Crystals are formed in one or more scraped wall crystallizers. A stirred growth vessel provides the needed residence time for the crystals to grow to a separable size. Crystals are separated from the mother liquor in one or more wash columns and subsequently melted to produce a high purity product.

Acrylic acid crystallization plant

Freeze concentration

Freeze concentration is a special application of suspension crystallization. Freeze concentration of food and beverage products leads to selective removal of water at sub zero temperatures. It is the preferred technology for supreme quality liquid food concentrates because all flavor and aroma components are retained. Typical applications are the concentration of juices, wine and beer, coffee and tea.



Skid mounted suspension crystallization plant for MDI

Unit operations — Membrane separation

Sulzer Chemtech is the world leader in pervaporation and supplies process solutions for a vast variety of applications including membrane filtration systems

Pervaporation

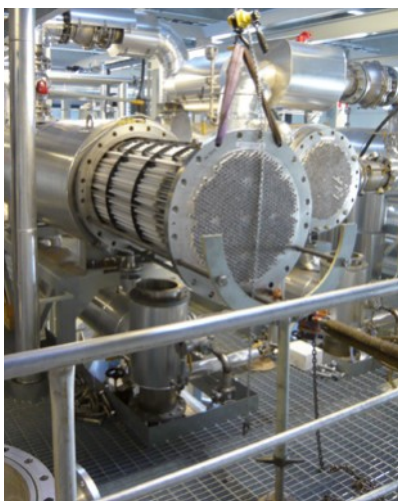
Pervaporation can be used to dehydrate solvents without the use of any third substance. Azeotropes can simply be split, irrespective of vapor-liquid equilibrium conditions and at low cost. In the same way, methanol can be removed from other organic solvents. A vacuum driving force is applied to the back side of the membranes, allowing almost complete removal of the permeating component (vapor). The feed to the membranes can either be in the liquid (pervaporation) or vapor phase (vapor permeation). Separation is predominantly affected by differences in polarity.

The process features of pervaporation are:

- Tailor-made membranes which selectively remove one or more components
- Flexible operation - a single unit can be designed to treat a large number of solvents with different component feed concentrations
- Flexibility for batch or continuous operation depending on the solvent properties and energy costs
- Possibility of process intensification via hybrid operation with distillation
- Standard skid mounted units

Key application areas are:

- Solvent production and recycling
- Dehydration of alcohols
- Production of active pharmaceutical ingredients (API's)
- Production of fine chemicals
- Production of flavor and fragrances
- Production of food and beverage



Ceramic membrane module

Membrane filtration

Sulzer Chemtech's membrane filtration systems are specifically suitable for the treatment of organic solvents and acids as well as for other advanced applications. Reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), microfiltration (MF) for aqueous systems, and organic solvent nanofiltration (OSN) systems can be supplied as a stand-alone unit operation, or in hybrid combinations with other technologies. Hybrid solutions offer a lower energy consumption, a smaller footprint, lower investment costs and lower heat effects on the product.

Typical applications for our pressure driven membrane filtration systems include:

- Concentration or purification of API's
- Catalyst recovery
- Clarification or concentration of organic and mineral acids
- Monomer / polymer separation
- Decolorization of solvents
- Recovery of spent solvents
- Solvent exchange



Skid mounted with membrane plant

Application technology

General overview

Over the years Sulzer Chemtech has built-up extensive experience in a broad number of applications

Application technology

Sulzer Chemtech has extensive experience in a wide range of applications. Many of these are based on our proprietary unit operations, or combinations thereof, the so-called hybrid processes. A non-exhaustive selection of applications we have extensive experience with is presented below. And there are many more.

Solvent recovery

Aqueous non-azeotropic systems:

- Methanol
- Acetone
- DMF / DMAC
- NMP
- Acetic acid

Other non-azeotropic systems:

- Methanol / ethanol
- Ethyl acetate / toluene
- DCM / ethyl acetate
- DCM / pyridine
- IPA / methoxyethanol

Heterogeneous azeotropic systems:

- Butanol
- Acetates
- MIBK, MEK
- Triethylamine
- Dichloromethane
- Toluene
- Xylene / water / methanol
- Hexane / water / methanol

Aqueous homogeneous azeotropic systems:

- Ethanol, IPA
- THF
- Acetonitrile
- Phenol
- Pyridine

Other homogeneous azeotropic systems:

- Ethyl acetate / cyclohexane
- Ethyl acetate / ethanol
- Methyl acetate / methanol
- DCM / methanol
- Methanol / dioxane
- Hexane / methanol / butane
- THF / ethyl acetate
- Decane / THF / ethyl acetate
- Methanol / xylene

Product purification

Vacuum rectification, stripping:

- Herbicide
- Octadecanol / additive
- Hydrogen peroxide
- Fatty acids and fatty alcohols
- Ethanolamine
- Glycols and glycol ethers
- MDA / MDI and TDA / TDI
- Halogenated and nitrated aromatics (NT, DCB, NCB)
- Xylenes
- Alkylphenols
- Caprolactam

Film evaporation:

- Amino acids
- Sugars
- Thioglycols
- Esters
- Fatty acids and derivatives
- Active Pharmaceutical Ingredients (API's)
- Resins

Liquid-liquid extraction:

- API's and vitamins
- Agrochemicals
- Flavors
- Wet purification of precious metals
- Food grade phosphoric acid

Crystallization:

- Acrylic and methacrylic acid
- Anthracene / naphthalene
- Alkylphenols, Bisphenol A
- Benzoic and phosphoric acid
- Caprolactam, DMT
- Chlorinated and nitrated aromatics
- Para- and meta-xylene
- Lactide
- Paraffin waxes
- Pyrrolidone
- MDI, TDI
- Sterol
- Trioxane
- Xylenol

Membrane separation:

- Removal of water / methanol from solvents
- Acetic acid / water

Wastewater and vent gas treatment

Sulzer Chemtech's solutions for wastewater and vent gas treatment feature regeneration techniques for the recovery of valuable components.

Steam stripping:

- Methanol, ethanol, butanol, IPA
- MTBE, isopropyl ether
- Ethyl acetate, butyl acetate
- MEK, MIBK
- DCM
- Dioxane, toluene

Liquid-liquid extraction:

- Acetic acid
- Phenol
- DMF, DMAC, NMP
- Agrochemicals and pesticides

Absorption, with water:

- Methanol, ethanol, IPA
- Acetone
- Ammonia

Absorption, with high boiling oil followed by steam stripping:

- Complex mixtures of, for example, hydrocarbons, alcohols, chlorinated hydrocarbons, ketones, ethers and ethers

Biofuels and biochemicals

Sulzer Chemtech is the leading supplier for the distillation of first generation biofuels, and is continuing its strong involvement for second generation biofuels and biorefineries.

Sulzer Chemtech has experience in the following fields:

- Mash / beer column (heavy fouling applications) and rectifier
- Dehydration of ethanol by pervaporation / vapor permeation, heat integrated with the overall process
- Membrane filtration (MF / UF / NF) before fermentation
- Liquid-liquid extraction for strong acid hydrolysis route
- Biodiesel



Freeze concentration unit for coffee

Food and beverage

Advanced distillation technology is applied in the food and beverage industry to recover and produce flavors, fragrances and vitamins. This requires processing of single chemicals to highly complex mixtures thereof. Products typically are temperature sensitive with close boiling points. In distillation this implies a high number of separation stages with low pressure drop. More than 300 industrial columns based on Sulzer Chemtech technology are in operation for the production of citral, menthol, citronellol, pinene, eugenol, tocopherol, limonene, and many other components.

Other examples of what Sulzer Chemtech offers in this field are:

- Mild film evaporation of temperature sensitive products
- Liquid-liquid extraction of vanilla, wine flavor, lemon and other essential oil
- Freeze concentration of beverages like fruit, vegetable juices and coffee
- Pervaporation to remove or concentrate aroma



Ethanolamine plant

Rectification and reaction

In addition to recovery and purification systems, Sulzer Chemtech offers selected chemical reaction process packages including downstream processing. The scope of supply typically consists of a basic engineering package and key equipment that is usually provided with process guarantees. A typical application where Sulzer Chemtech has specialist process know-how is the production of ethanolamines.

Continuous reaction is another field where Sulzer Chemtech has gained substantial know-how. For continuous cascade reactions various types of static and agitated multi-compartment reactors have been developed. The main advantages of a continuous reactor compared to a series of stirred vessels are a compact design, a long overall residence time and a narrow residence time distribution.

Application technology

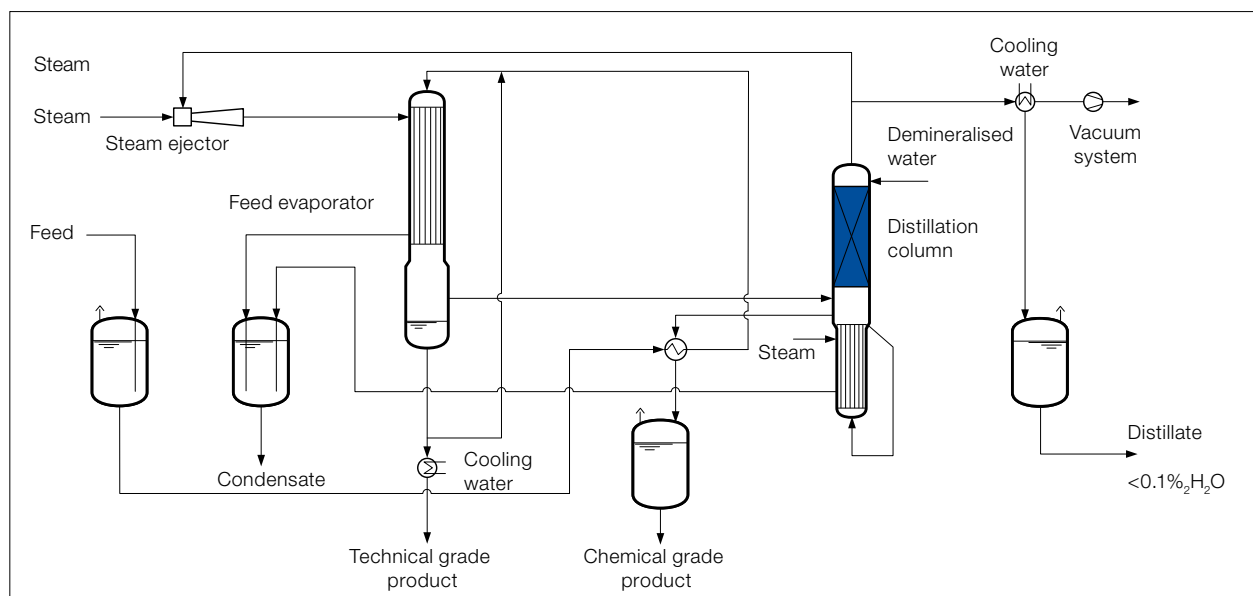
Two typical examples

The following examples give a taste of our collection of successful applications

Hydrogen peroxide

Following its production, hydrogen peroxide is concentrated by partial dehydration via distillation. The main features of Sulzer Chemtech's hydrogen peroxide concentration concept are its operational safety, flexible product purity and low energy consumption. Our plants are designed to produce the entire range of hydrogen peroxide purities required by the market. The addition of a feed evaporator even enables our customers to simultaneously produce hydrogen peroxide of different purities.

A cornerstone of Sulzer Chemtech's H_2O_2 concentration concept is the implementation of very high safety standards by a combination of features including low liquid hold-up, pressure drop and operating temperature, provision of a safety water tank and rupture discs, and an appropriate process control. This unique approach to safety has gained worldwide acceptance and has made Sulzer Chemtech the market leader in hydrogen peroxide with more than 40 distillation plants in operation.



Hydrogen peroxide distillation with feed evaporation

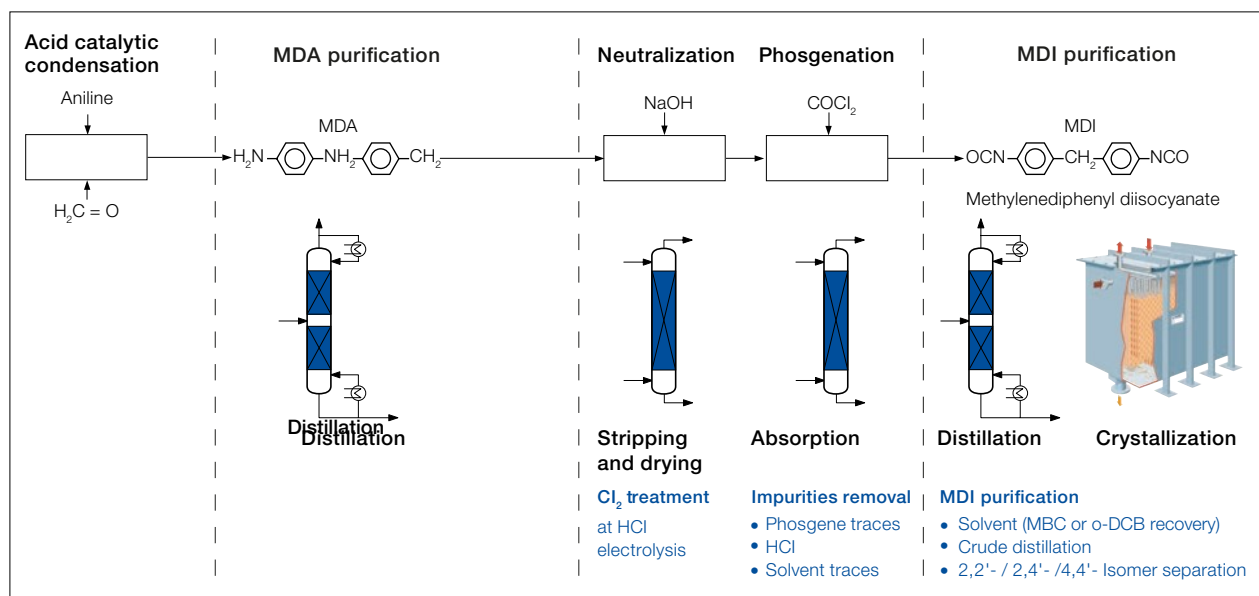
MDI purification

Methylene diphenyl diisocyanate (MDI) is one of the most commonly used sources for polyurethane production. In addition to MDA (methylenedianiline) purification, Sulzer Chemtech offers specialized MDI purification and isomer separation processes. Our MDI purification technology is well proven with a current installed base of more than 30 industrial plants using Sulzer Chemtech's distillation and/or crystallization technology.

MDI has the tendency to form dimers during the purification process. Therefore, low temperature, pressure drop, residence time and liquid hold-up are all determining criteria for the distillation as well as for the final product quality. The use of Sulzer Chemtech's BXPlus™ gauze packing in combination with dedicated distributors optimizes these factors, thus minimizing dimer formation.

Suspension crystallization is an incomparably gentle ($T_{\max} \sim 40^\circ\text{C}$), robust and flexible process. It enables the MDI product purity to be tailored to particular end-use applications. A product purity of at least 99.5% is reached in just one crystallization cycle. Higher product purities can be achieved by further sweating, or by repeating the crystallization cycle. Suspension crystallization ensures a colorless product, even in cases of process upsets in the synthesis section.

Suspension crystallization can be added downstream of the distillation unit in existing plants, thereby boosting overall processing capacity. For a new MDI plant, the optimized process integration of distillation and suspension crystallization leads to a maximum in operating flexibility in terms of capacity and product quality, and a substantial reduction of capital and operating costs.



MDI process

Application technology

Polymer production technology

Sulzer Chemtech's continuous polymer production technology delivers an optimum product quality while featuring a high flexibility in production and low operating cost

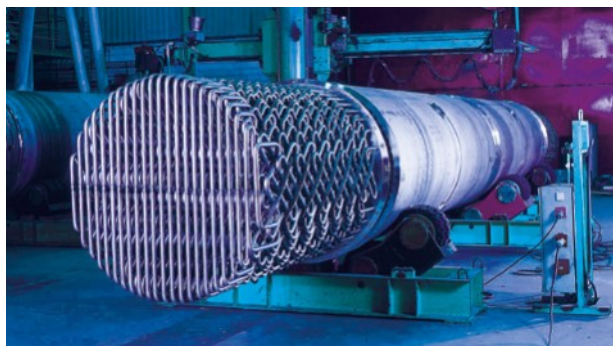
Sulzer Chemtech's novel technologies for continuous polymer production largely benefit from the in-house static mixing and heat exchanger technologies as well as from the system integration know-how.

Continuous polymerization reaction technologies

Highly exothermic polymerization reactions require accurate temperature control along the reaction. The unique geometry of the Sulzer mixing reactor (SMR™) is highly suited for an accurate control of the polymerization temperature and also optimizes mixing.

Other characteristics are:

- Continuous polymerization reactions
- Plug flow behavior
- High conversion rate
- Homogeneous high polymer product quality
- Ability to process polymers with a viscosity up to 10'000 Pa·s
- High heat exchange surface area to reactor volume ratio of up to 120 m²/m³
- High flexibility to switch production to a different polymer grade
- Reliable scale-up



Sulzer mixing reactor (SMR™)

Devolatilization technology

Efficient removal of monomer, solvent and other impurities after the reaction section is mandatory to avoid too high VOC (Volatile Organic Compound) levels in the end-product. Sulzer Chemtech's proprietary degassing technology is based on a single, or multiple stage flash devolatilization process. Each stage features a heat exchanger with Sulzer Chemtech's proprietary SMXL™ mixer inserts, a stripping agent dosing mixer, and uniquely designed degassing chambers that contain special polymer distributors.

The technology is further characterized by:

- Highly efficient VOC removal to meet the most stringent industrial and legislative standards
- Prevention of polymer degradation by minimizing residence time and avoiding high temperatures and shear
- Narrow residence time distribution
- Moderate capital cost (no moving parts)
- Low operating costs

Upgrading technology

After devolatilization, additives can be mixed into the polymer melt to upgrade the final product. Sulzer Chemtech has many years of experience in providing successful upgrading solutions for improved product quality and profitability. Sulzer Chemtech's static mixing technology (SMX™ and SMX™ plus) makes mixing of highly viscous polymers with low viscosity additives possible, for viscosity ratios of up to 10 million.

Other features of our proprietary mixing devices include:

- High mixing efficiency
 - Prevention of polymer degradation by avoiding high shear forces
 - The use of static equipment, no moving parts
 - Low investment and operating costs
- Sulzer Chemtech's sophisticated heat exchanger technology is also applied in cooling the highly viscous polymer product (SMR™, SMR™ plus, SMXL™ and SMXL™ plus).



Sulzer static mixer-heat exchanger (SMXL™)

Application technology

EPS and PLA technology

Sulzer Chemtech has developed unique, state-of-the-art technologies for the production of Expandable Poly Styrene (EPS) and biodegradable Poly Lactic Acid (PLA)

Sulzer Chemtech's SMR™ reaction technology can be applied to the production of:

- Polystyrene (PS, EPS, GPPS, HIPS)
- Poly lactic acid (PLA) and other biodegradable polymers
- Styrene copolymers (ABS, SAN)
- Polymethyl methacrylate (PMMA)
- Polyethylene (PE)
- Polypropylene (PP)
- Silicon polymer
- Polyamide 6 (PA6)
- Terpene resins
- Polyoxymethylene (POM)

EPS technology

In Sulzer Chemtech's EPS technology a blowing agent, for example pentane, is continuously dosed into a bulk flow of crude polystyrene, prior to pelletizing. This technology includes the proven advantages of the in-house mixing technology. The EPS beads can be produced according to a narrow size distribution. Our EPS technology can be applied to a wide range of polystyrene grades (HIPS, GPPS) with the flexibility to produce specialty grades containing, for instance, color particles or flame retardants. EPS finds its application in heat insulating construction materials,

consumer goods packaging and civil engineering.

PLA technology

Biodegradable polymers based on renewable feedstocks have started to replace conventional polymers produced from fossil fuel. Sulzer Chemtech now offers a complete plant solution for a PLA polymerization process which was jointly developed with Purac. Lactide monomer is polymerized in a continuous, fully integrated process using Sulzer Chemtech's proprietary SMR™ technology and equipment. This state-of-the-art PLA production technology has advantages compared to standard technologies:

- Very efficient polymerization process using static mixer technology
- Short time requirement to switch to a different PLA grade due to low residence times
- Operational flexibility to produce different PLA grades with different molecular weights
- Compact-size plants
- Straight-forward scalability to bigger plant sizes
- Low maintenance costs due to the installation of mainly static equipment

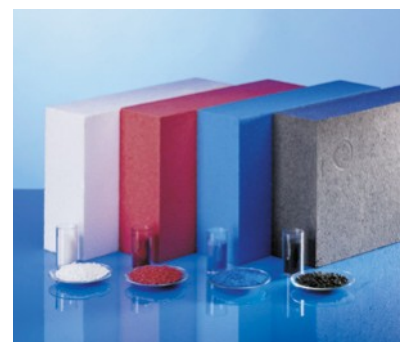
As of 2012 Sulzer Chemtech will have its own 1'000 t/yr PLA production unit on-stream. This unit will produce various customer-specific grades and provide clients the option to obtain larger quantities of sample material for their own in-house evaluation and product development. The main applications for PLA are in packaging, electrical housings, fibers and materials resistant to temperatures of up to 200 °C.

Testing facilities

Tailored to our polymer production technology, Sulzer Chemtech maintains world class pilot plant facilities for testing of mixing effects, heat transfer, polymerization reactions and devolatilization, in order to secure reliable equipment design and desired process performance.



Skid mounted production unit for biodegradable polymer (PLA)



Examples of EPS

Process plant solutions

From first concept to guaranteed plant performance

Sulzer Chemtech is a high quality, full service provider that includes laboratory and pilot plant testing, studies and conceptual designs

Test center services

Sulzer Chemtech's state-of-the-art test centers cover both laboratory and pilot scale units for the complete range of in-house unit operations including the polymer production technology. Mobile test units are also available. Feed material for testing is supplied by our customers, who in return may receive samples of the tested end-products for their own research and development activities, or to support the introduction of a new product into the market. For these purposes samples may also be produced in larger quantities. Testing supports conceptual design work and serves as a basis for appropriate technology and equipment selection. It supports designs with a plant performance guarantee. Test facilities of various scales are available for:

- Distillation
- Film evaporation: Falling film, thin film and short path evaporators
- Liquid-liquid extraction: All column and mixer-settler types extractors
- Fractional crystallization: Static, falling film and suspension crystallization, freeze concentration
- Membrane separation: Pervaporation and vapor permeation, pressure driven membrane filtration up to 80 bar (reverse osmosis, nanofiltration, ultrafiltration and microfiltration)
- Polymer production (reaction, devolatilization and upgrading steps), of EPS and PLA specifically

Most of the listed unit operation facilities can also be combined in-line to test these as hybrid process solutions. The majority of all the required analyses, including of chemical compositions and

physical properties can be performed with dedicated in-house equipment.

Studies and conceptual designs

Sulzer Chemtech provides specialist process engineering services to support clients in their key process developments and decision making. In this area we offer the following services:

- Feasibility studies
- Process conceptual designs
- Plant optimization, debottlenecking and revamp studies involving, for example, increase of plant capacity, improvement of product specifications or reduction of operating costs

We develop process solutions for both new and existing plants. Our excellent capabilities are based upon our extensive experience with and in-depth knowledge of all separation technologies and process applications within our portfolio. This includes a full understanding of inherent system capabilities and know-how of relevant properties of components and mixtures thereof. Process simulation and a detailed check of existing plant conditions form part of the activities. The optimum process is developed based on a structured and analytical screening of all possible solutions. We are unique in solving an even wider range of separation challenges by combining unit operations into hybrid process solutions. We bring in our specific know-how in the field of special distillation technologies like heat pumps

and heat coupling, multi-effect and reactive distillation. While developing concepts we closely cooperate with our customers and listen to their requirements.

Process guarantees

The most promising process solution is confirmed by laboratory and pilot plant testing. Testing may have the following purposes:

- Process validation
- Consideration of the effect of unknown or trace components
- Optimization of operating parameters
- Verification of process stability
- Screening of equipment
- Supporting of scale-up

The successful completion of tests enables Sulzer Chemtech to offer its plant solutions with full process guarantees.



Sulzer Chemtech is excellent in developing a process concept into an installed plant solution operating with a guaranteed plant performance

Sulzer Chemtech is a full service provider for proprietary key equipment and process plant solutions. Our excellent position comprises an extensive know-how and long-standing experience in developing process concepts into installed plant solutions operating with a guaranteed performance.

Basic engineering

As soon as the customer has agreed upon the conceptual design it can be further developed into a basic engineering package for a commercial size plant. At this stage we bring in our expertise and capabilities in scaling-up pilot and demonstration plants into commercial size process units. A basic engineering package typically consists of:

- Process flow diagrams (PFD)
- Heat & mass balance
- Piping & instrumentation diagrams (P&ID's)
- Equipment specifications
- Instrument specifications
- Functional design specifications for plant control and safeguarding

- Preliminary equipment layout
- Capital cost calculation for skid mounted units
- Capital cost estimate based on factors when the total project scope consists of a basic engineering package plus key equipment only

Detail engineering

For skid mounted units, upon approval of the basic engineering package, the project moves into the detail engineering phase, resulting in:

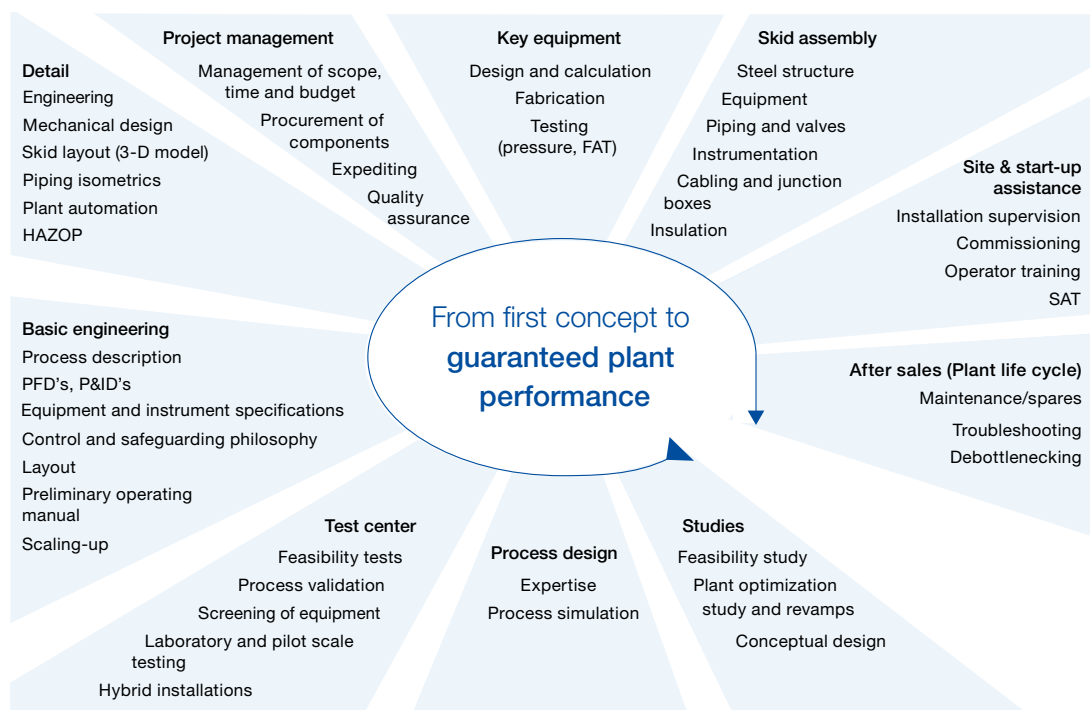
- P&ID's final for construction
- Equipment and instrument specifications final for construction
- Mechanical drawings for key equipment
- 3-D plant model
- Piping isometrics
- Plant automation concept

A review of the 3-D plant model can be made with the customer. It is also common practice to participate in customer's Hazard and operability study (HAZOP) as part of our engineering services.

Project management

All of the above activities are performed by highly qualified and experienced in-house staff. We rely upon our people and strive for business excellence. Project teams work under the guidance of the project manager who has overall responsibility for the project budget, schedule and quality. Throughout the entire project, the project manager remains in close contact with the customer.

In all its activities Sulzer Chemtech employs an efficient quality assurance system which is accredited in accordance with the latest standards of ISO9001 for quality, safety, health and environment. Standard procedures, protocols and test documentation are used from initial design to the final plant performance test and ensure a continued high quality result.



Process plant solutions

From first concept to guaranteed plant performance

Sulzer Chemtech delivers state-of-the-art proprietary equipment for its process solutions and has a specific long-term experience in fabrication, installation and start-up of process units

Proprietary equipment

All proprietary and key process equipment is produced either in our modern workshop or sourced from approved and certified sub-suppliers. Our in-house fabrication fulfils all applicable requirements and design codes, being European, US, or other. The range of construction materials includes stainless steel, special alloys as well as titanium, zirconium and tantalum.

Skid mounted plants

Specific know-how has been built-up over the past 25 years by supplying more than 250 skid mounted modules in Europe, Asia and the USA. Skids are assembled in our modern, purpose-built workshop or at selected, certified sub-contractors. Typical maximum skid sizes are 4 x 4,5 x 25 m. Larger plants consist of more than one module.

The modular assembly includes the installation of:

- Steel structure
- Equipment
- Piping and valves
- Instrumentation
- Cabling and junction boxes
- Insulation

Advantages of skid mounted, turnkey plants are:

- Short delivery time through an integrated fast track execution
- Low overall investment costs
- Reduced on-site erection and hook-up time and thus minimal site disruption
- Manufacture of the complete plant under workshop conditions ensuring the highest quality
- Completion of the factory acceptance test (FAT) prior to delivery
- Qualification tests prior to plant delivery



Transport and installation

Sulzer Chemtech has a team of highly experienced installation supervisors, who provide construction support services for site-built plants, and for the off-loading and installation of skid mounted plants. These supervisors liaise closely with the customer's construction manager, safety officer and mechanical contractor, to ensure a safe and trouble-free installation.

Commissioning and start-up

Following completion of all mechanical and electrical tie-ins to the plant, Sulzer Chemtech's process engineers are mobilized to undertake plant commissioning. The commissioning team is usually headed by the process engineer responsible for the plant design. Plant commissioning follows a structured plan and ends with the start-up of the process unit followed by a site acceptance test (SAT). Training of customer's operators often takes place in parallel.

Plant hand-over

At hand-over of the plant's care, custody and control, the customer is provided with final, as-built documentation including operating manuals, final layout drawings and certificates. A dedicated after sales group ensures the support for spare parts and services during the whole lifetime of the plant.

Starting from hand-over the client can benefit from its optimal performing plant solution based on Sulzer Chemtech process technology.



The Chemtech division is the global market leader in innovative mass transfer, static mixing and polymer solutions for petrochemicals, refining and LNG.

Chemtech is also leading the way in ecological solutions such as biopolymers as well as textile and plastic recycling, contributing to a circular economy. Our product offering ranges from technology licensing to process components all the way to complete separation process plants. Customer support ranges from engineering and field services to tray and packing installation, tower maintenance, welding and plant turnaround projects – ensuring minimal downtime.

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