schulz partner verfahrenstechnik GmbH

Thermal Process Engineering

ENGINEERING COMPLETE PLANTS
APPARATUSES

- Distillation
- Evaporation
- Rectification
- Extraction
- Crystallization
- Drying

Company

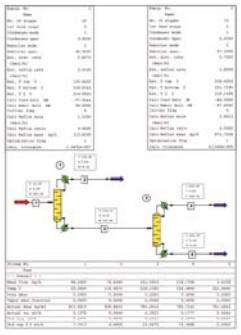
Schulz + Partner GmbH

Since its foundation in October 1994, Schulz+Partner GmbH, a process engineering company, has specialized in the treatment and regeneration of industrial process liquids.
As a competent and experienced systems supplier, we design and implement customized solutions in accordance with your personal needs and requirements.

1994 Schulz+Partner GmbH is founded
1997 Schulz+Partner joins Ebner Group
2003 Merger with Künzi ACS AG

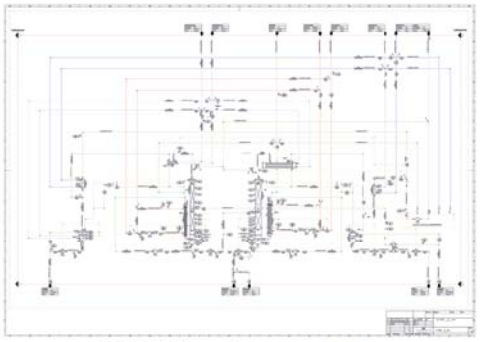
Development and Innovation

Optimal designs and plant safety are ensured by process simulation coupled with extensive lab and pilot plant testing. Moreover, we are dedicated to continuous further development and integration of innovative technologies. This puts us in a position to satisfy the highest customer demands in the long term, combining economy with guaranteed operational safety.



Process simulation

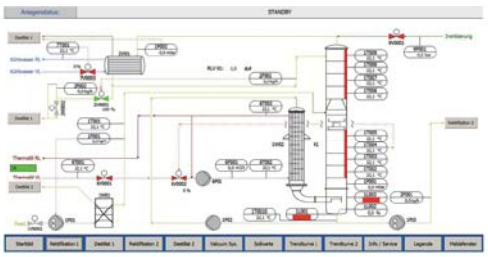
Pilot- plant testing



P&ID Flow sheet

3D construction

Erection / Assembling



Startup

FIELDS OF ACTIVITY

Engineering

- Process solutions & consulting
- Lab/pilot-plant testing
- Process simulation
- Profitability analyses
- Preliminary projects
- Basic and detail engineering
- Risk analyses
- Installation planning, 3-D
- Automation and Visualisation
- Material procurement
- Installation & project Management
- Commissioning

Plant engineering

- Turnkey plants
- Pre-assembled Skid units
- Process stages
- Special plants
- Single components
- Peripheral devices

After-Sales-Service

- Service contracts, especially for heat-pump units
- Spare parts express delivery service

Evaporation

- Natural / Forced circulation evaporator
- Falling-film evaporator
  Vapour recompression evaporator
- Multistage evaporator
- Thin-film evaporator
- Heat-pump evaporator

Fields of application

- Acids / lyes concentration
- Solvents
- Oil / viscose solution

Drying/Crystallization

- Thin-film drying
- Crystallization evaporation

Fields of application

- Electroplating waste water
- Disposal leachate
- Zirconium
- Healing salt

Rectification / Absorption

- Tray and structured packing column
- Washer
- Absorption column

Fields of application

- Separation of solvents
- Ammonia stripping

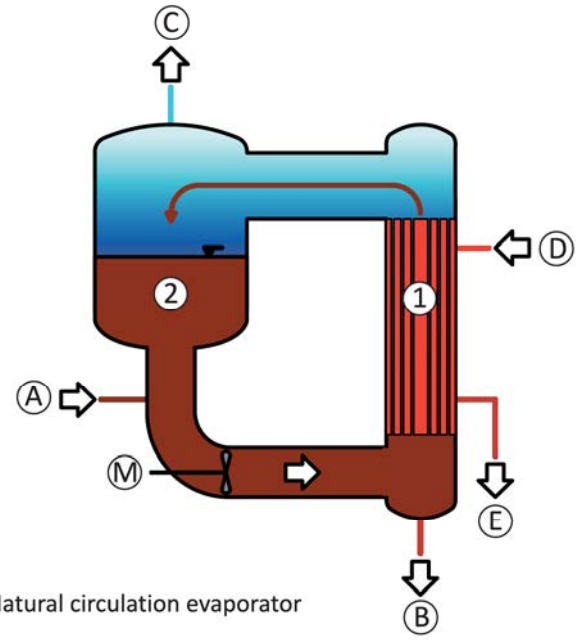
Liquid-liquid extraction

- Agitated extraction column
- Mixer-Settler
- Multistage reaction column

Fields of application

- Waste oil recycling
- Various solvents
- Acids

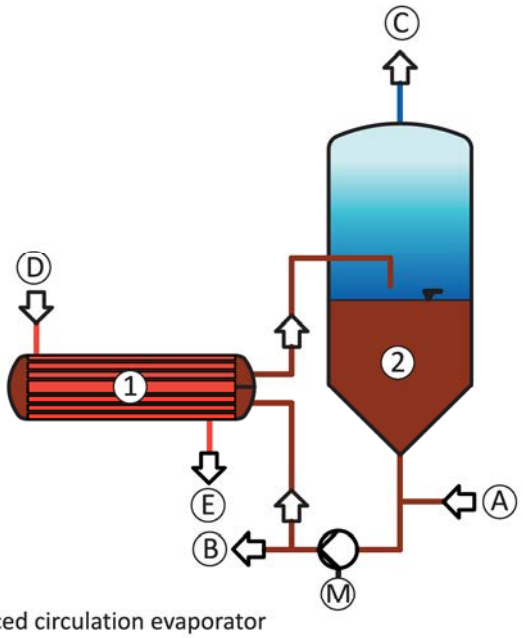
Evaporation



Natural circulation evaporator

Natural circulation evaporator

operates by the "thermosiphon" principle, in which no circulating pump is usually required. They can be used for processing practically any low-viscosity liquid. In the case of solutions with low heat transmission (due to higher viscosity, for example), a pump (such as an elbow pump - see diagram) may be required to ensure sufficient circulation.



Forced circulation evaporator

Forced circulation evaporator

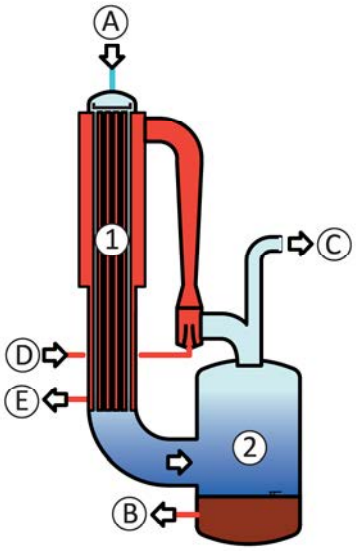
is required for contaminated media or high-viscose products. Compared to natural-circulation processes, the evaporation will not take place in the heat-exchanger tube, only in the separator (flash evaporation). The pump pressure ensures that the product is not evaporated but just heated up by a few degrees when passing through the heat exchanger. This prevents precipitation and tube encrustations. Due to the basic design without any moving parts, forced and natural circulation evaporators are extremely robust and safe to operate.

Falling-film evaporator

- Universally applicable, thus suitable for most evaporation tasks.
- Compact design allows implementation of apparatuses with very large heating surfaces.
- Due to their minimal holdup and correspondingly low residence time (on the product side the evaporator tubes are wetted with just a thin film), these plants are specially suitable for the evaporation of heat-sensitive products.
- Low pressure loss combined with good heat transfer characteristics make these evaporators ideal for use with thermal or mechanical vapor recompression. The result: highly energy-efficient evaporating plants.

Vapour recompression evaporator

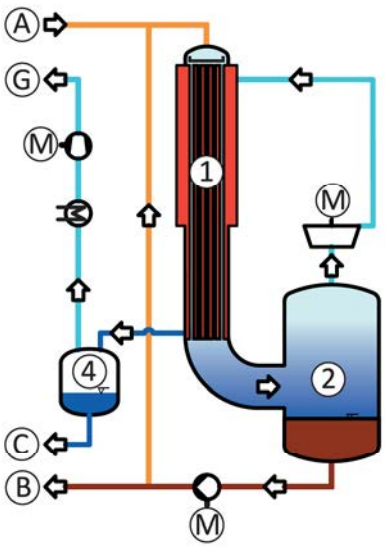
There are different ways to reduce the required energy for evaporation. One of these is the so-called vapour-recompression evaporation. Depending on the type of compression used, energy savings of up to 95% can be achieved. Vapour recompression simply means pressurizing the vapour produced by the evaporation and subsequently feeding it back as heating steam.



Falling-film evaporator with steam-jet vapour recompression

Thermal vapour recompression

A venturi steam-jet compressor operated with steam is used for vapour pressurization. Venturi steam compressors have no movable parts and are therefore extremely resistant and reliable. Depending on operating conditions, steam savings of up to 50% can be achieved.
A disadvantage of steam jet compressors is their lack of flexibility under changing operating conditions.



Falling-film evaporator with mechanical vapour recompression

Mechanical vapour recompression

Mechanical vapour recompression uses compressors of various designs (e.g. reciprocating, screw type, Roots-type or axial compressors, axial fans). During operation, no additional heating steam is usually required. The electric power input, which is used to repressurize the generated steam to a higher level, amounts to just 10-20% of the energy needed for single-stage evaporation. All compressors operate at high to very high rotational speeds, depending on the type used, and are therefore very noisy. Sound insulation is usually necessary

Legend

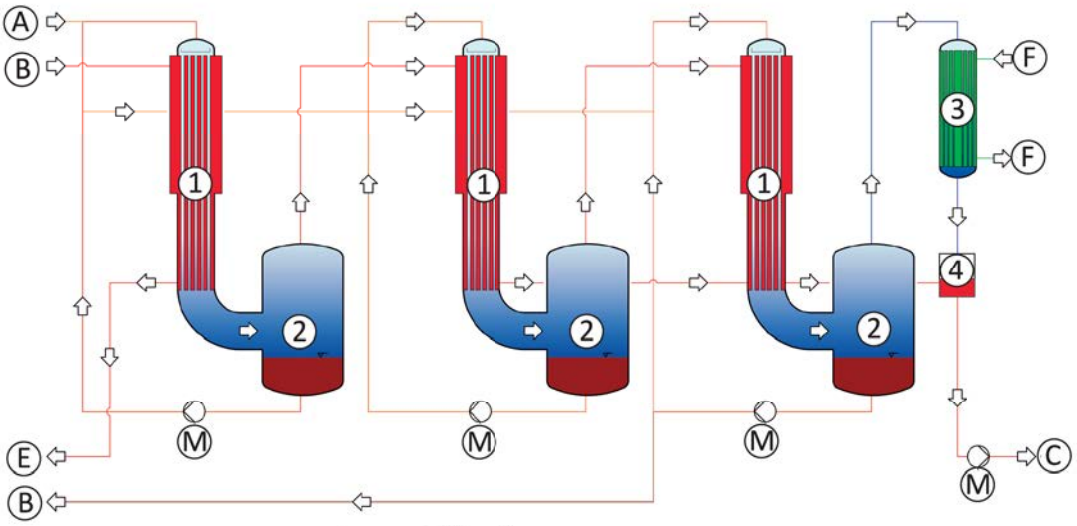
1 Heat exchangers
2 Separator
(3 Condenser)
4 Discharge vessel

A Feed
B Residue
C Destillat
D Steam
E Steam condensate
(F Cooling water)

Evaporation

Multi-stage Evaporators

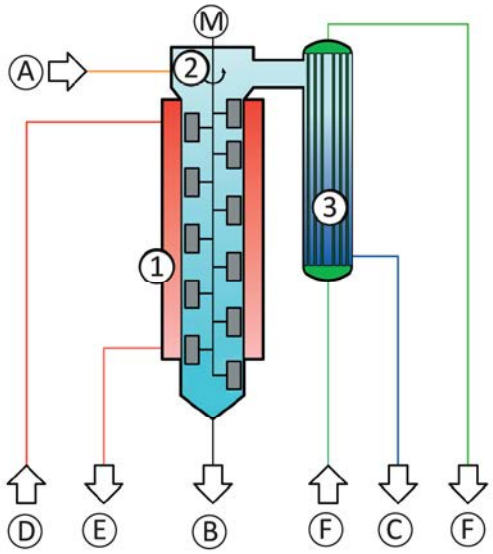
Besides thermal or mechanical vapour recompression, the specific energy requirement can also be achieved with multi-level evaporation. Based on the principle that the vapour produced in the first evaporator is used for heating up the next evaporator and so on. The more evaporator stages are available in series, the less steam is consumed. A three-stage evaporator, for example, requires less as half as much heating steam as a single-stage evaporator. The basic investment costs, though, are correspondingly higher.



3-stage Falling-film evaporator

Thin film evaporators

The thin film technology includes all thermal processes in mechanically produced thin films. Depending on the application, different types of thin film evaporator have been developed for specific uses. The typical thin film evaporator consists of a tubular heat transfer area with an external heating jacket and a fast-rotating, inner rotor with flexible or rigid wiper Elements. The driving speed is adapted to the particular specification and task.



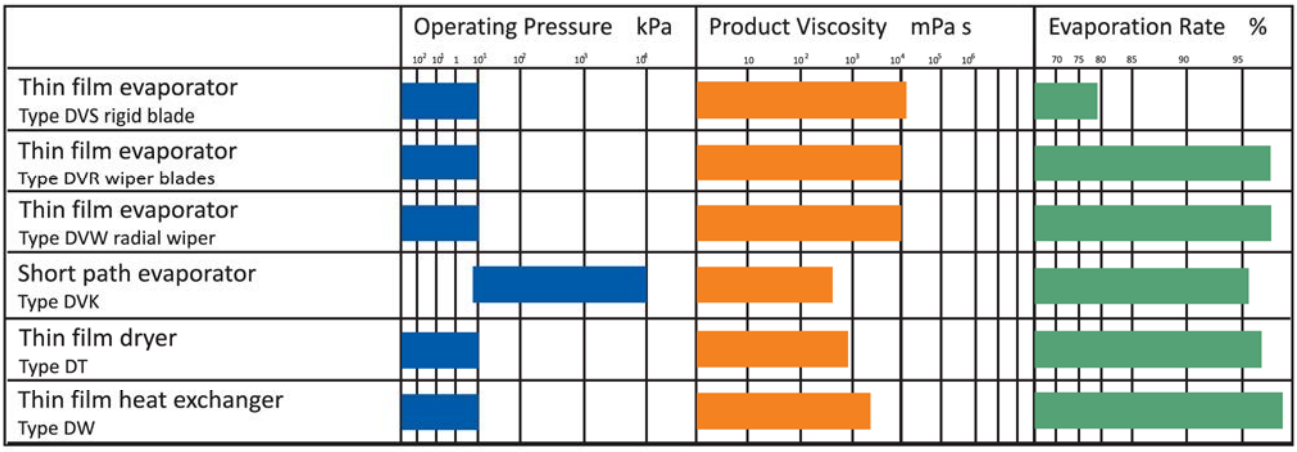
Advantages:

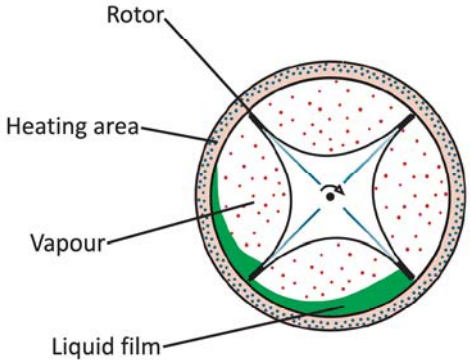
- Good heat conductivity (k-value), even when working with highly viscous and contaminated products
- Minimal thermal stress, thanks to low operating capacity, therefore a short dwell time (10-20 s mean dwell time)
- No dead zones, here fore overheating prevented and a constantly high product quality guaranteed
- Permanent mechanical cleaning of the heating surface prevents incrustations

Legend

1 Heat exchangers
2 Separator
3 Condenser
4 Discharge vessel

A Feed
B Residue
C Destillate
D Heating Steam
E Condensate
F Cooling water

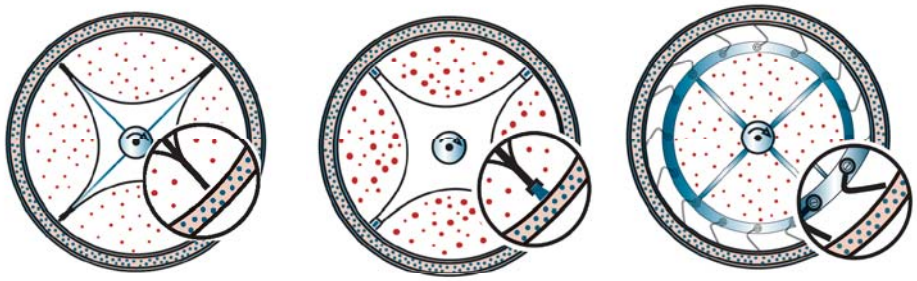




Typical uses for thin film apparatuses include

- Concentration of highly viscous products, polluted liquids, salt solutions, oils, resins etc.
- Use as sump evaporator for vacuum rectification columns (minimum pressure drop).
- Sludge drainage
- Degasing, removal of volatile components (monomers) from highly viscous products, melts and pastes

Depending on the process and the product involved, different types of rotor are used:



Type	Rigid blades DVS	Radial wiper DVR	Wiper blades DVW
Rotor speed	high	low	low
Wall contact	no	yes	yes
Necessity of bearing lubrication	yes	no	no
Temperature range	max. 300°C	max. 250°C	max. 400°C
Viscosity	max. 40.000 mPa s	max. 20.000 mPa s	max. 20.000 mPa s
Evaporation grade	max. 80 Vol.%	max. 98 Vol.%	max. 95 Vol.%
Solid content (suspension)	no	low	low
Crystallisation	no	no	low

Evaporation

Heat pump evaporators

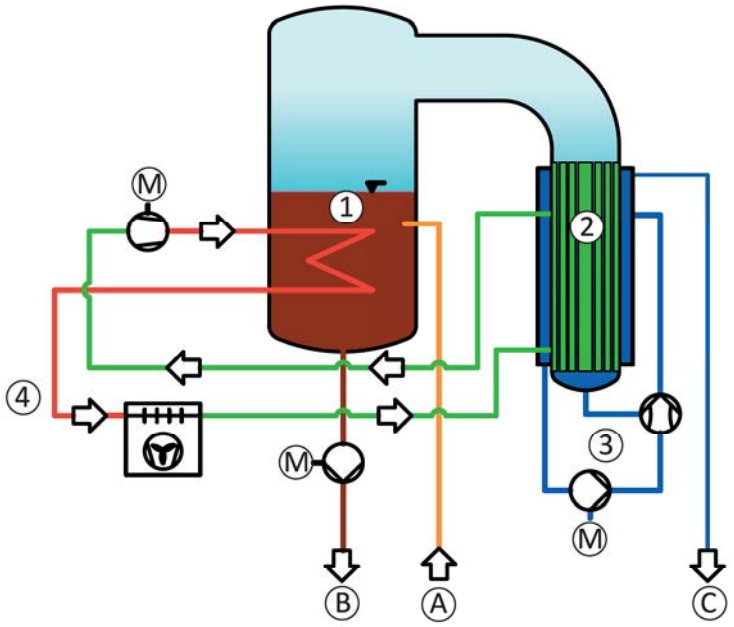
The working principle

Heat pump evaporators operate on the basis of a compressor-driven refrigerant circuit. As the name indicates, the system "refrigerates" (or cools) on the low-pressure side while generating an equal amount of heat on the high-pressure side. Where refrigeration is the sole objective, such heat is normally dissipated into the ambient atmosphere. Our heat-pump evaporators, in contrast, utilize both the heat output and the refrigerating capacity in a complementary manner: the heat generated is used for evaporation, while the "cold" output is simultaneously employed for vapour condensation. This explains the exceptional 90% efficiency of these evaporators. Apart from the power for the compressor, the plant requires no further energy input at all.

EVA BASIC

Natural circulation evaporator

This type of plant is used for smaller volumes of process liquid and for simple tasks. Evaporation takes place on the coiled tubes in the evaporator. This system is also called nucleate boiler, because small bubbles detach from the heat exchanger surface and increase in size while rising. This results in high turbulence in the liquid, and liquids free of solids can be quite highly concentrated this way. This type of system is highly safe to operate and has a low energy consumption.

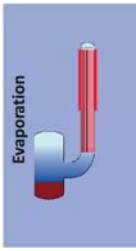


Process Description

The feed product (A) is sucked into the concentration stage (1) under level control. The vacuum required is generated by a vacuum system (3) consisting of a water-jet vacuum pump and a circulation pump. On the high-pressure side, the overheated, gaseous refrigerant gives off condensation energy that is transferred to the feed product via a heat exchanger forming an integral part of the concentration stage (1). In this process, the feed product heats up and part of its water content evaporates, thus concentrating the product to a point where it is still free-flowing.

The vapours are liquefied in the condenser (2), and the coolant evaporates in the process. The condenser is designed in a way that it cools the distillate of the vacuum system at the same time (patented heat exchanger). The distillate is conveyed to a receiver via the vacuum system.

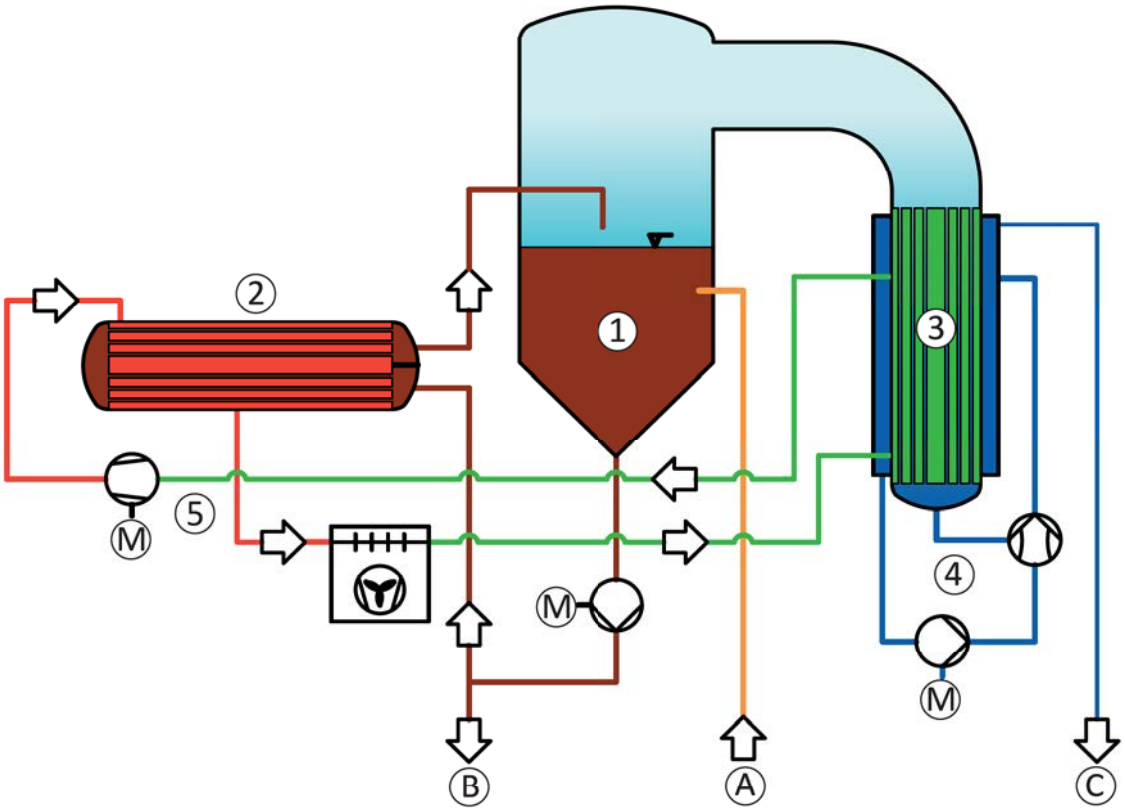
Interesting solution for the chemical industry



CONfix®

Forced circulation evaporator

This forced-circulation evaporator is recommended if heating-surface deposits caused by evaporation must be prevented. Obviously, this is the right solution when reprocessing crystallizing and deposit forming liquids that easily lead to encrustations on the heating surfaces. This unwelcome effect can be controlled - and at least delayed - by increasing the speed of the feed product circulation through the tube bundle. To this end, a circulating pump is used to deliver the product through an external heat exchanger into the flash vessel. The product is only moderately heated without boiling when passing through the heat-exchanger, to be subsequently evaporated in the flash vessel. This minimizes deposits and encrustations. This type series is also a better solution than its EVA natural circulation counterpart when dealing with higher viscosities or when the process inevitably generates higher boiling temperatures.



Highlights of this Heat pump evaporator

- 90% energy saving
- Self-contained systems
- Low boiling temperature <50°C
- Preassembled and tested systems
- Only electricity required as energy carrier
- Adaptation to each application

Evaporator

Acids

Nitric acid (HNO_3)
Sulphuric acid (H_2SO_4)
Hydrochloric acid (HCl)
Hydrofluoric acid (HF)
Phosphoric acid (H_3PO_4)
Chromic acid (CrO_3)
Formic acid (HCOOH)
Their mixture and more

Alkalis

Caustic soda (NaOH)
Potassium hydroxide (KaOH)
Ammonia solution (NH_4OH)

Heat-pump evaporator H_2SO_4 + H_3PO_4

Forced circulation evaporator 84% H_3PO_4

Heat-pump evaporator H_2SO_4 + H_3PO_4 + Al

Used material:

High-alloy steels
Hastelloy
Titanium
PVDF
PTFE
Inliner (PTFE)
Gumming
Coating
Graphite

Fields of application

Forced circulation evaporator HNO_3 + HF

Forced circulation evaporator H_2SO_4 85% + HF

Heat-pump evaporator ATEX H_3PO_4, H_2O + Ethanol

Evaporator

Various solvents

Methanol, Ethanol, Butyl glycol, Isopropanol, White Spirit, Toluene, Xylene, Naphtalene and more

Fall-film evaporator methanol biodiesel 1150kW

Steam generator for various solvents 2350kW

Heat-pump evaporator White Spirit, ATEX, silicone-free

Heat pump evaporator Butyl glycol, ATEX, silicone-free

Fields of application

Oils/viscous media

The behaviour of oil when concentrated to remove water and solvents is often difficult. It may be accompanied by foaming and also strong differences in viscosity. Frequently, higher temperatures are required to achieve a very low residual water content.

Forced circulation evaporators; separation of water from hydraulic oil. Viscosity up to 20.000 mPa s.

Falling-film evaporator
viscous pharmaceutical substance

3 stage Falling-film evaporator
viscous products 800kW

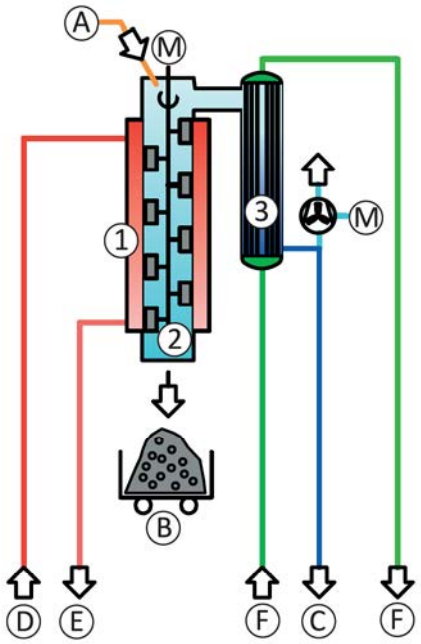
Thin-film evaporator
high viscose products 6,3m²

Evaporation

Drying / Crystallisation

Thin film dryer

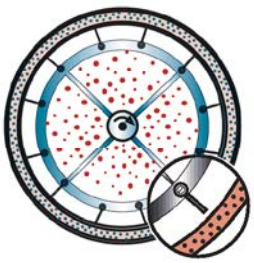
Continuous drying in a thin film dryer usually delivers a powdery product which seems to be absolutely dry, but actually still contains residual moisture in the range of a few percent. The pendulum wiper arms of the rotor work without wall contact at a gap of approx. 0.5 mm. The system can be operated at ambient pressure and under vacuum. However, the solids discharge via a cellular wheel sluice is costly.



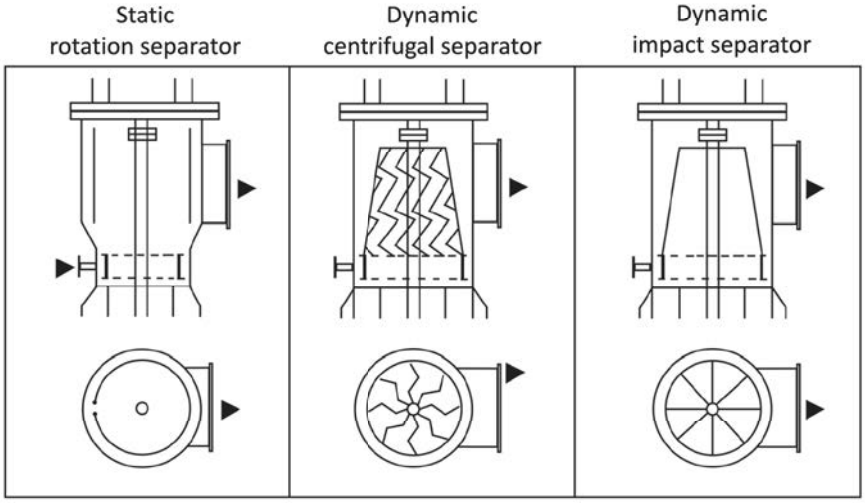
Legend

1 Evaporator heating zone
2 Rotor
3 Condenser

A Feed
B Residue
C Distillate
D Steam
E Condensate
F Cooling water



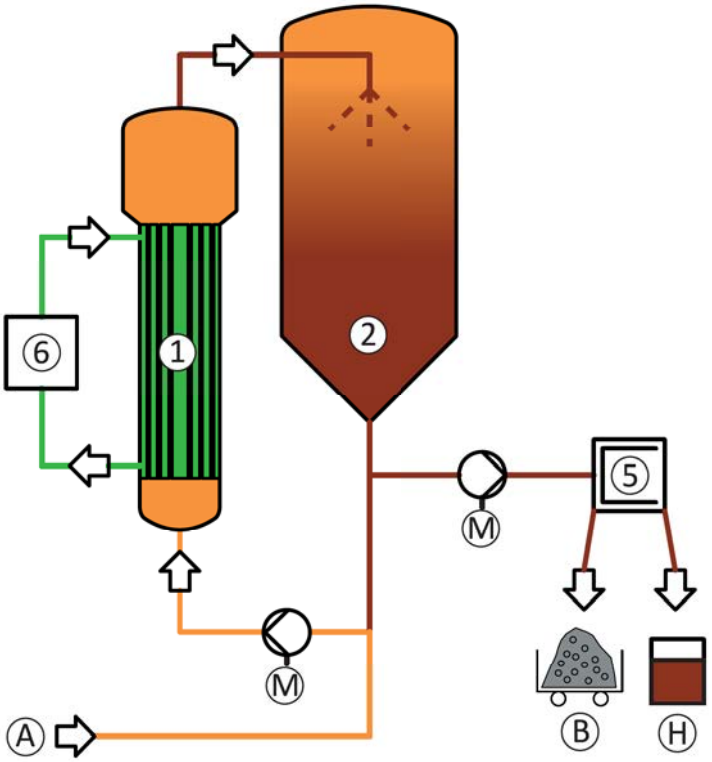
Type	Pendulum blades DT
Rotor speed	high
Wall contact	no
Necessity of bearing lubrication	no
Temperaturbere range	max. 400°C
Viscosity	max. 15.000 mPa s
Evaporation grade	max. 95 Vol. %
Solis content (suspension)	high
Crystallisation	high



Droplet separator variants

Crystallisation

Crystallisation occurs as soon as the temperature-dependent saturation concentration has been exceeded. This can be achieved either by evaporation or by cooling of the concentrated solution. Continuous or discontinuous plant operation is possible.



Legend

1 Heat exchanger
2 Crystalliser
5 Centrifuge
6 Cooler

A Feed
B Crystals
H Mother liquor

Evaporating crystallisers

- Used for diluted solutions
- With heat pump; requires only electric power - no heating medium, no cooling water
- With vapor compression
- Crystalliser combined with single- or multi-stage evaporation

Cooling crystallisers

- Cooling by flash evaporation into vacuum (flash crystallisation)
- Cooling with heat exchanger, especially for discontinuous operation
- Cooling with self-cleaning heat exchanger, thanks to fluid-bed technology

Drying / Crystallization

Thin-film dryer disposal leachate

Droplet separator

Rotor

Thin-film dryer electroplating waste water

Fields of application

Multistage crystallisation evaporator healing salt

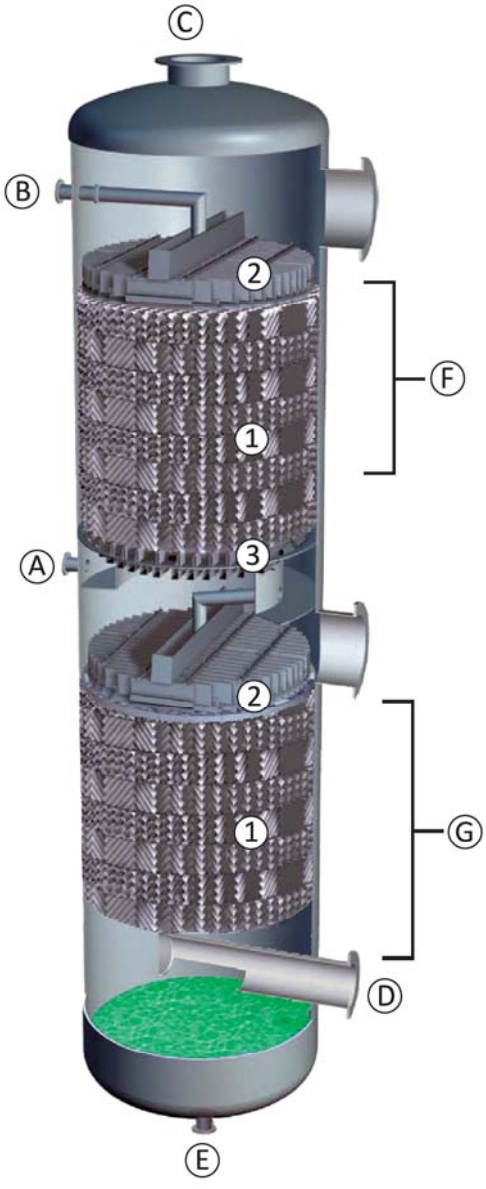
Crystallisation HNO_3 + HF + ZrF

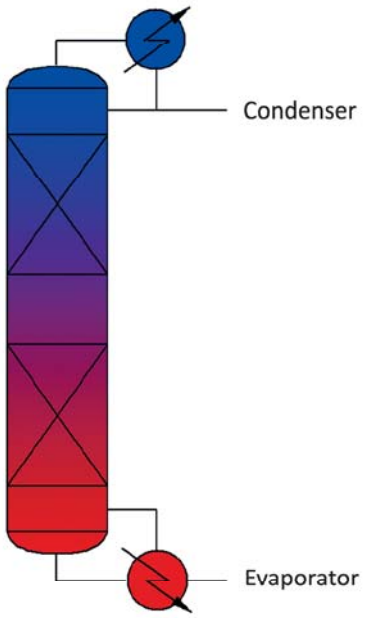
Crystallisation evaporator zirconium

Rectification-Absorption

The process

Rectification is the most widely used separation process in the field of chemical engineering. Separation methods are a step up from standard distillation. The separation effect compared to distillation is many times higher. The rectifier column is operated with less energy requirement and less technical effort and it is more space-saving than connecting several single distillation apparatuses in series.





Legend

1 Packing
2 Liquid distributor
3 Liquid collector

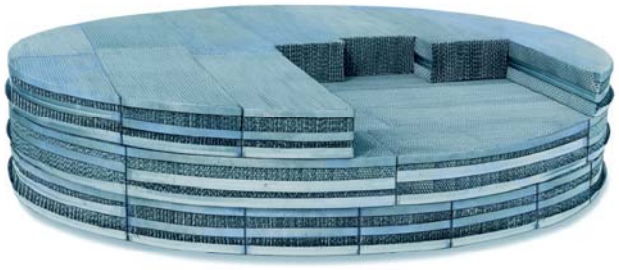
A Product feed
B Return feed
C Steam outlet
D Steam inlet
E Swamp outlet
F Stripping section
G Stripping section

The product is transported into the column between the stripping and the rectifying section. Then a multi-level separation takes place between high boilers and low boilers in the counter flow. In this process, the low boilers accumulate in the rectifying section and in the head of the column and are subsequently liquefied in a condenser. A part of this distillate is transported back to the column and improves the separating capacity as return flow. The high boilers that accumulate on the bottom are transported to an evaporator. The resulting steam is returned to the column and gives off its energy to the continuously fed low boilers in the feed.

Packed columns

- Structured wire-mesh and metal-sheet packings
  Random packings
- Liquid distributors, collectors and supports
- Revamping of existing columns on a time-optimized basis to minimize interruption of the client's production processes

Advantage:
- Low pressure loss
- High separation efficiency



Structured sheet packing

Packing columns

- With all common packing types for simple separation tasks

Advantage:
- Low investment costs
- Simple installation

Packings

Tray columns

- Bubble-cap and tunnel trays
- Valve trays
- Trays with cooling/heating coils
- Perforated plates

Advantage:
- No need for collectors and liquid distributors; feed inlets or side stream outlets may be located at any plate.
- Type "KSB" perforated plates - a generic S+P design. Thanks to a spacing of just 200 mm (5 practical trays/m = 4 theoret. plates/m) and the elimination of collectors and distributors, the resulting stack will be lower than a packed column low model height efficiency.
- Insensitive as structured packages

KSB jet-tray

Scrubbers / Absorption columns

- For exhaust air or process gases
- Random or structured packings

Rectification-Absorption

Rectification plant with thin-film evaporator
(vacuum 100 Pa)

Solvent regeneration

Ammonia stripping

Fields of application

Amine separation

Isopropanol separation

Mounting a packing

Liquid collector

Liquid collector

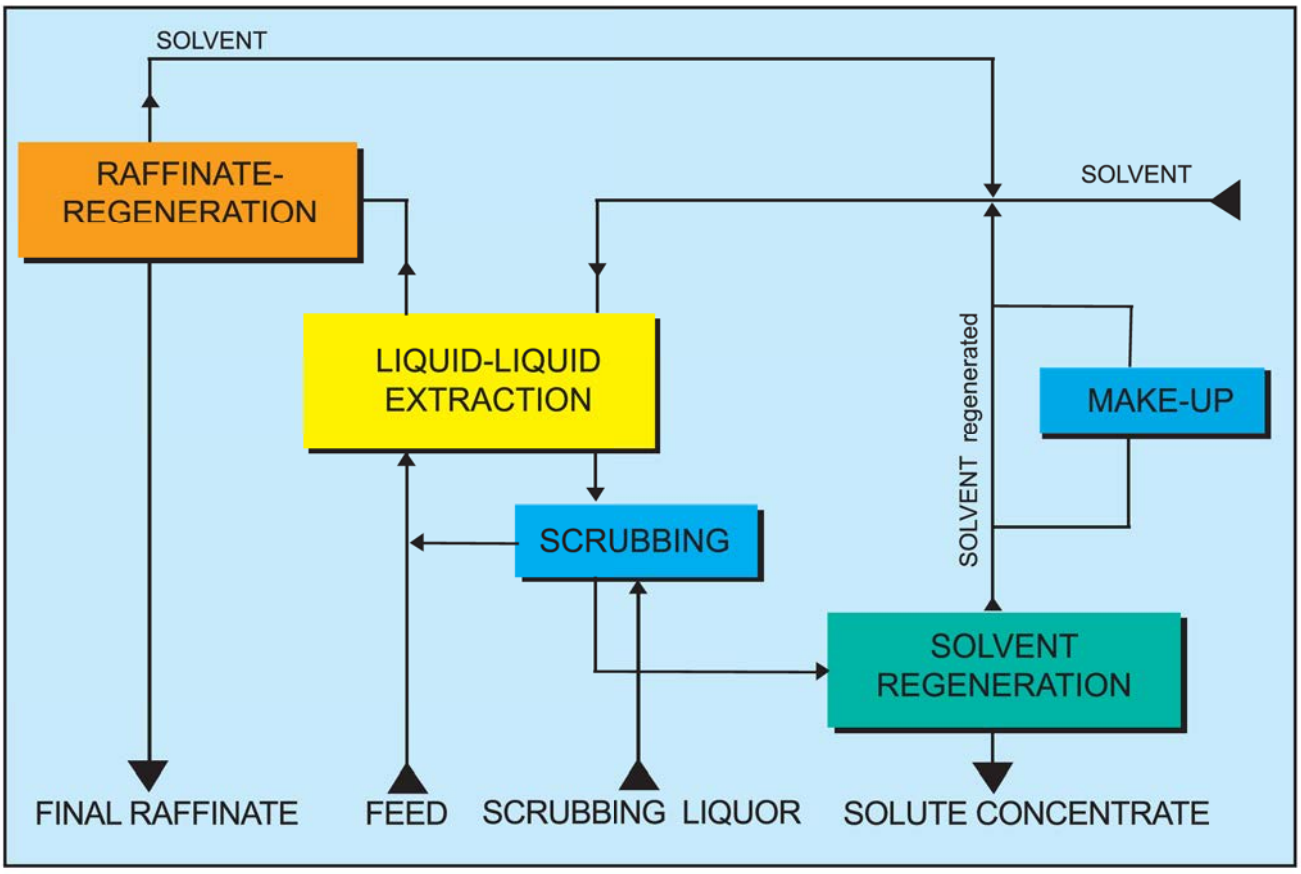
Rectification / Absorption

Liquid-liquid-extraction

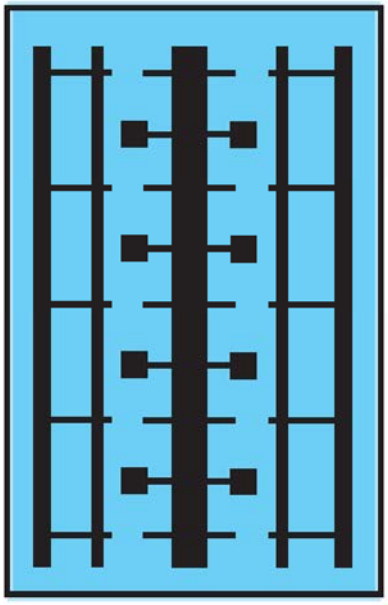
The Process

Liquid-liquid-extraction is a separating technology, based on the distribution of one or more components between two immiscible or almost immiscible liquids. Generally, one of the liquid phases is water and the other an organic solvent. However, there are other well-known systems where both phases are organic or organic mixtures. Liquid extraction, also known as solvent extraction, is especially suitable for the processing of large capacities. For this reason, this operation is frequently used in the oil industry.

Throughputs from 100 m^3/h or and even higher can be treated with extractors of reasonable size. Although energy consumption for the normal extraction process itself is almost negligible, the attached steps for the recovery of solvent require more or less energy, depending on the nature of the components and the difficulty of separation. Often, not only the extract phase but also the raffinate phase has to be processed by washing, distillation or another follow-up treatment.
The complete extraction process with solvent regeneration and raffinate treatment needs a quite complex plant with the corresponding investment cost. For the selection of a suitable solvent, one has to consider not only the extraction selectivity, but also the ease of handling and regeneration, the solubility in the raffinate, the product cost, etc.



Flowchart: Application of liquid-liquid-extraction



Principle agitated column

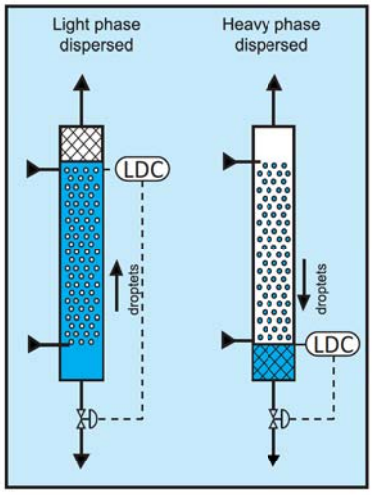
Agitated extraction columns

As no other type, the agitated extraction column is universally suitable for practical all kind of extracting applications. Limiting condition is a minimal density difference of 0,05 kg/m3 between both phases and a not to strong tendency to form a stable emulsion, in order to allow a smooth agitation..

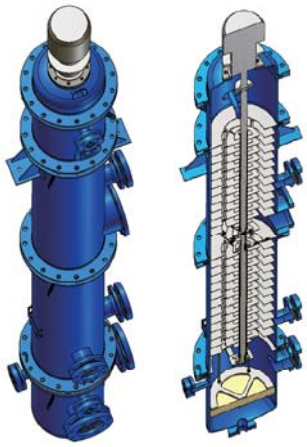
Advantage:

- Adaptation of the compartment and agitator geometry to the specific product and the operational process conditions
- The optimal droplet size can be adjusted by variation of the agitator speed
- Alternatively heavy or light phase dispersed
- The mechanically simple construction together with the extremely small agitator speed gives, minimal apparatus costs, minimal maintenance costs, minimal energy consumption

Pilot plant columns



Possible operation conditions



CAD-Model

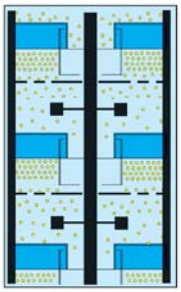
Reliable Scale-UP

The safe transfer of small scale test results to larger product units is an important advantage of the agitated extraction column. The be- haviour of the agitators regarding droplet dispersion and liquid flow follows clear and well known relationship, valid for small as well as for large scale units. Droplet size and axial mixing depending of the agitating intensity and the compartment geometry have been investigated in innumerable test runs. The result are practically applicable mathematical rules.

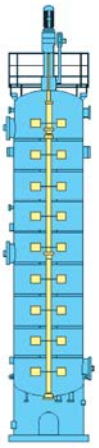
Liquid-liquid-extraction

Agitator

Stator mounted in column shell



Mixer-settler column



Multi stage reaction column

Principle agitated column

This type of column stands out because it can be modified to the process requirements by adapting the compartment and agitator geometry

Product and operating conditions
- Products composition
- Capacities
- Densities
- Viscosities
- Interfacial tension

Adaptable column geometry
- Column diameter
- Free cross-sectional area of compartment separating plates
- Compartment height
- Agitator diameter
- Agitator blade height

Adaptable operational parameters
- Agitator speed
- Service temperature

The agitator unit (shaft with agitators and baffles) can be pulled out through the column top as a whole without dismantling the remaining construction.

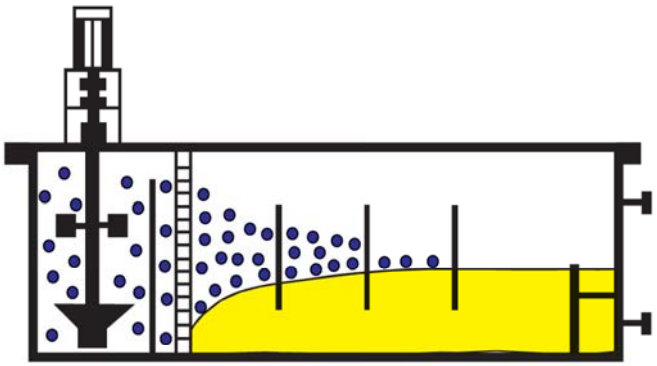
Special types

The **mixer-settler column** is a superposed mixer-settler battery. Unlike a normal mixer-settler, the agitators of all mixing compartments are arranged on one central shaft and driven by a motor. As in a normal mixer-settler, there is a complete decantation of the two phases in each stage.

Preferred applications:
- Extraction systems with extremely slow mass transfer, often guided by a parallel reaction (e.g. metal extractions)
- Extreme phase ratios

Multi stage reactor column type MCR
- Suitable for carrying out homogeneous and heterogeneous (2-phase) reactions
- Corresponds functionally to a agitated vessel cascade

Mixer-Settler



- Preferably used where only a small number of stages (1 to 4) is required
- High stage efficiency of 80–100%
- Each stage features an independently adjustable agitator. This allows stage-wise adjustment of the dispersion intensity and thus an optimisation of the required decanting volume
- Operation can be interrupted anytime, to be resumed later without any additional start-up time
- Mixer compartment with pump-mix turbine (flow inducing) and additional dispersion agitator (6-blade). Thanks to a relatively low agitator speed, the formation of finest droplets is prevented and the required settler volume reduced.

Depending on construction materials and operational requirements, special models are available:

Type MSB
Box-type, with rectangular ground plan; available as single stage or „battery-type“ multiple stages (arranged side by side) materials:
all weld able metals, plastics, plastic/GFR

Type MST
Tube design, single or multi stage batteries.
Design for higher operation pressures

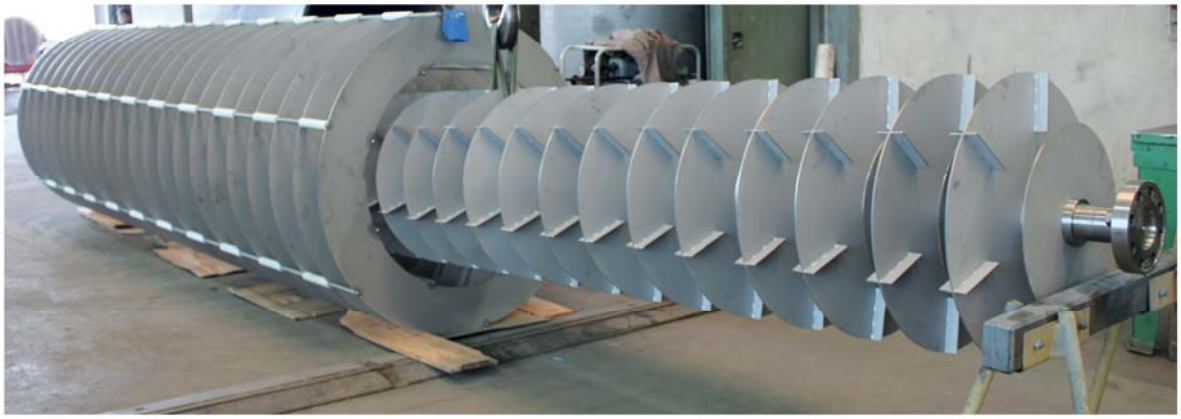
Type MSV
Agitated-vessel shape, with centric mixer and externally arranged settler.
Single stage or max. 3 stages per vessel. Design for higher operation pressures.
Compact design

Liquid-liquid-extraction

Agitated column with solvent recovery

3 stages mixer-settler type MSV

Oil recycling/ diameter decanter ø 3m / height 26m



Stator / rotor

Fields of application

Diisopropyl Ether / Isopropanol

Glass lined steel column with
Hastelloy C4 + C22 / PVDF Internals for
corrosive solutions hydrochloric acid

3 stage mixer-settler battery Type MST

Pilot plant station

We advise and support our customers in the development of their processes, ranging from the selection of the operating materials and the laboratory and pilot tests up to the design of the entire system.

Many thermal processes can be tested and informative samples produced on our test systems. The pilot plant is adapted to your individual requirements. This enables us to guarantee the design of the processes and the associated product qualities.

Available are:

- Rotating evaporators
- Falling-film evaporators
- Natural circulation evaporators
- Forced circulation evaporators
- Heat pump evaporators
- Thin layer evaporators/dryers
- Rectification columns
- Extraction columns
- Mixer-settlers

Please unfold !

Heat pump evaporators

Falling-film evaporators, rectification columns and extraction columns

After Sales Service

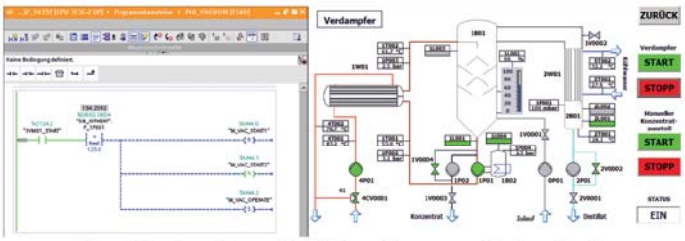
We will gladly assist you with ordering spare parts and maintenance work after delivery. Maintenance agreements ensure that specified tests are reliably performed in the set intervals.

By means of remote maintenance, we are able to troubleshoot quickly and allow a continuous operation. This way, we can minimise your production downtimes and ensure high system availability.

System alarm

Data transfer via internet

Teleservice PC Schulz+Partner



Troubleshooting with SPS software and visualisation

Service

service preparation and purchasing spare parts

FIELDS OF ACTIVITY

ENGINEERING
Trouble shooting, Consulting
Laboratory/pilot testing
Process development
Process simulation
Basic and detail engineering
Risk AnalysisInstallation planning 3D
Measuring and control engineering
Automation, procurement of materials
Assembling and supervision ,startup
Operator instruction

PLANT CONSTRACTION
Skid plants
Process units
Pre-assembled skid-units
Plant equipment

AFTER-SALES-SERVICE
Service contracts for all delivered plants and external plants
Spare part support

EVAPORATION
Natural-/ Forced circulation evaporator
Falling-film evaporator
Multistage evaporator
Thin film evaporator
Vapour recompression evaporator
Heat pump evaporator

CRYSTALLISATION / DRYING
Evaporation crystalliser
Thin film dryer

RECTIFIKATION / ABSORPTION
Packed column
Scrubber
Absorption column

LIQUID-LIQUID-EXTRACTION
Extraction column, agitated
Mixer-Settler
Multistage reaction column

CONCENTRATED ON SOLUTIONS

schulz partner verfahrenstechnik GmbH

SCHULZ + PARTNER GMBH
VERFAHRENSTECHNIK
CARL - ZEISS - STR. 11
D - 79331 TENINGEN
TEL +49(0)7641 95 95 700
Fax +49(0)7641 95 95 701
INFO@SCHULZPARTNER.COM
WWW.SCHULZPARTNER.COM