schulz partner verfahrenstechnik GmbH

LIQUID-LIQUID-EXTRACTION

ENGINEERING · APPARATUS · COMPLETE PLANTS

AGITATED COLUMNS

MIXER-SETTLERS

MULTI COMPARTMENT REACTORS

THERMAL PROCESS ENGINEERING

LIQUID-LIQUID-EXTRACTION

GENERAL

Liquid-liquid-extraction is a separating technology that is 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 100,000 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.

ADVANTAGES

OF LIQUID-LIQUID-EXTRACTION

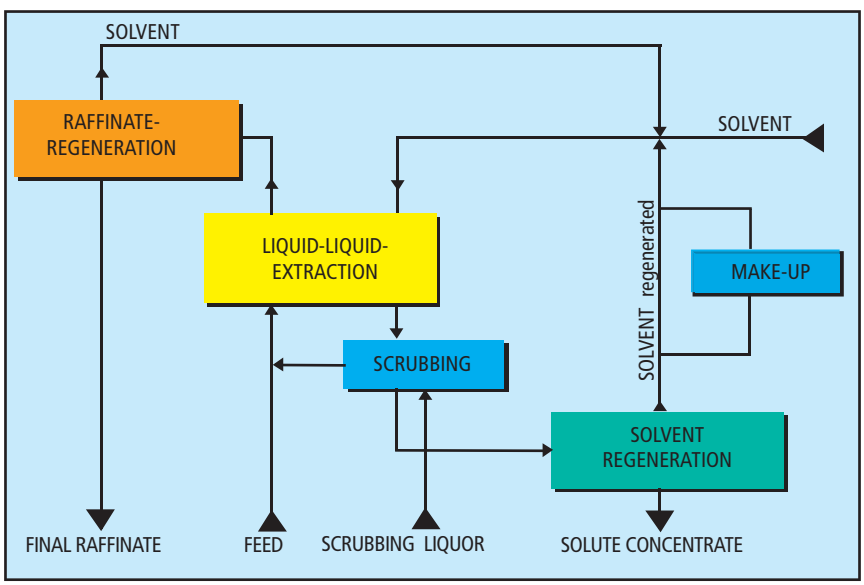
Very large capacities are possible with a minimum of energy consumption (for example: separation of paraffines and aromatics in the oil industry)

Selectivity, when other standard separation methods (such as rectification) fail or require expensive equipment or energy cost
(example: production of water-free pyridine)

Heat sensitive products are processed at ambient or moderate temperatures (example: vitamin production)

Separation of small contents of high-boiling impurities, mostly in aqueous solutions. In the normal thermal separation technique, the complete water content has to be withdrawn by a very energy-intensive evaporation process (example: elimination of phenol from aqueous waste)

Flowchart: Application of liquid-liquid-extraction

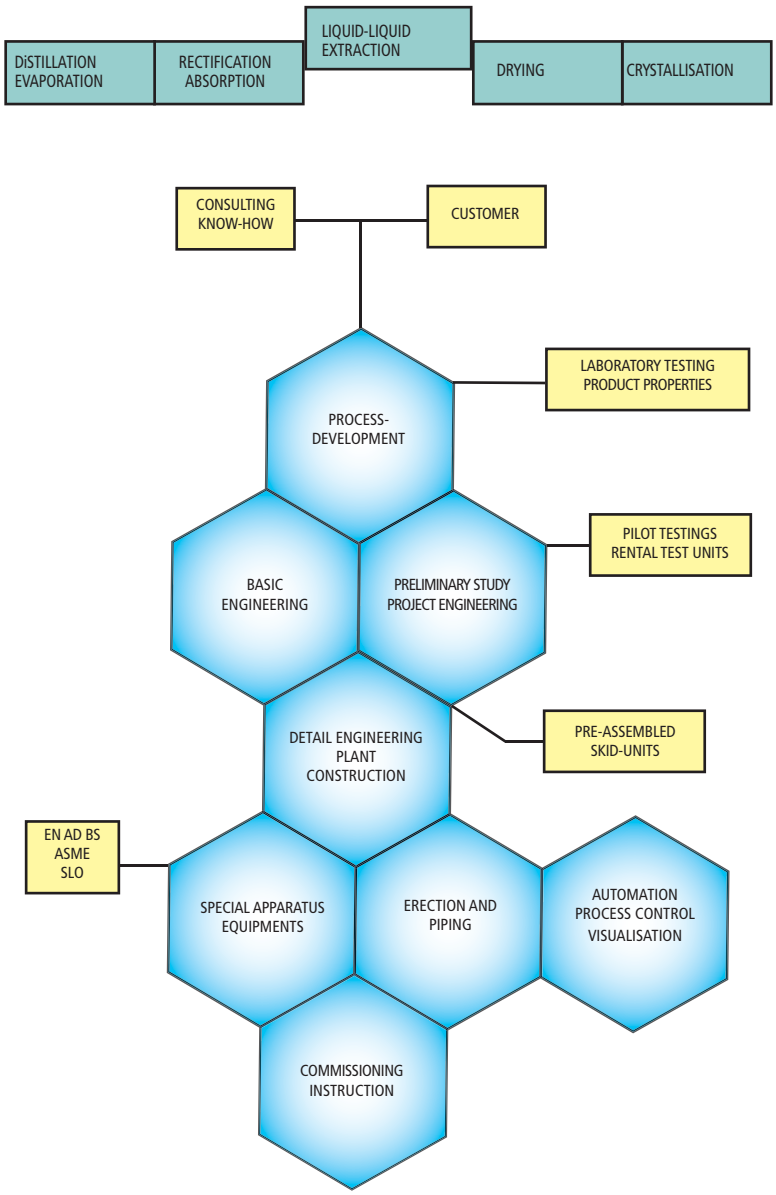


PROCESS DEVELOPMENT

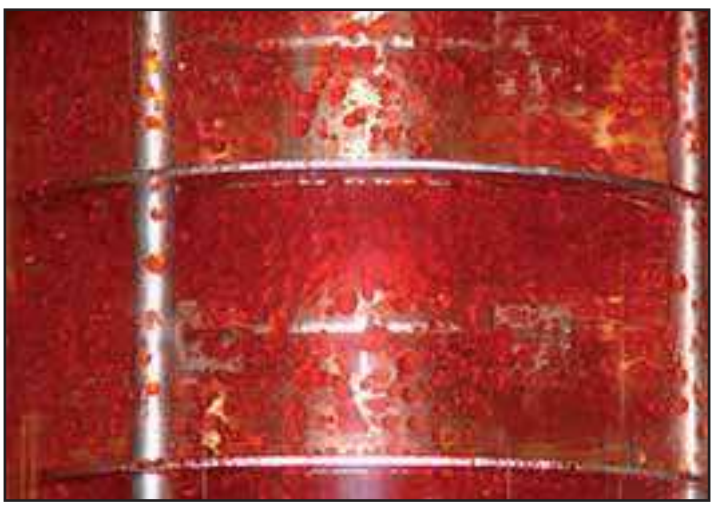
PRODUCTS AND SERVICES

Schulz+Partner offers the entire range of services related to liquid-liquid extraction. We advise and assist our customers in the development of their processes. We help them to choose a suitable extraction solvent, we propose and carry out laboratory and pilot tests that take extraction as well as regeneration into account. Last but not least, we plan and deliver the suitable equipment or the entire plant.

Our know-how is based on practical experience gained from a large number of processes carried out with extraction equipment. The performance of an extractor is the result of a multitude of factors that depend on component data, mass transfer and flow conditions. Single effects can be treated quite easily, but there is a problem when several effects occur with interactions, as it happens in liquid-liquid extraction. Therefore, and despite the availability of computers and simulation programs, testing and experience still determine the safe design of an extraction process.



Pilot plant at S+P pilot plant station



AGITATED EXTRACTION COLUMNS

FUNCTION

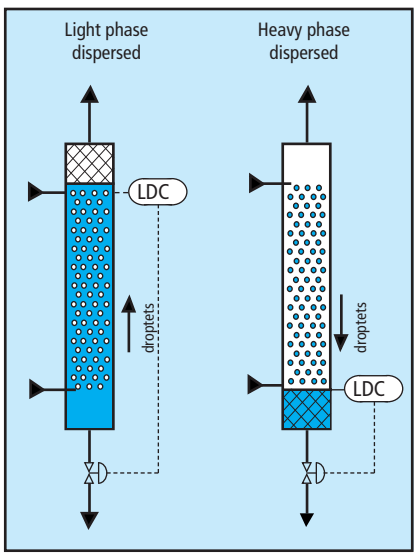
As no other type, the agitated extraction column is universally suitable for practical all kind of extracting applications. Limiting condition is a minimal density difference of 0,05 kg/m^3 between both phases and a not to strong tendency to form a stable emulsion, in order to allow a smooth agitation.

Advantages:

- Adaptation of the compartment and agitator geometry to the specific product and the opera tional process conditions
- The optimal droplet size can be adjusted by variation of the agitator speed
- Insensitive to solids
- 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



Scheme left: Comparison of dispersion, light and heavy phase

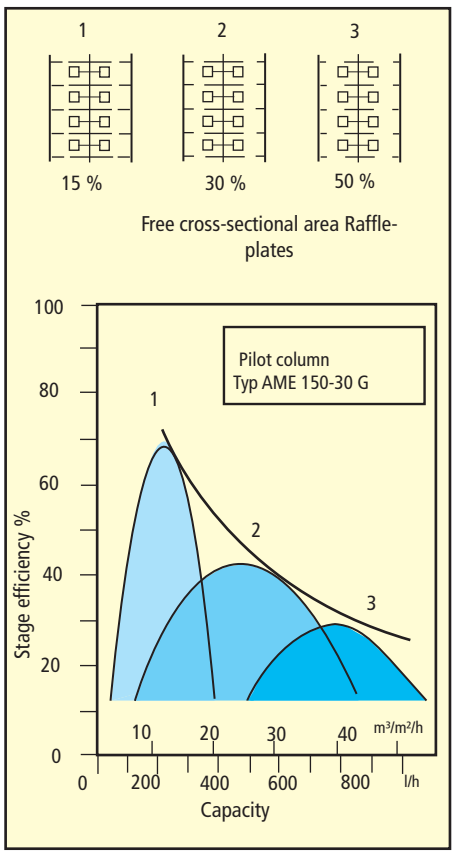
at the top: Drive of extraction column
beneath: Extraction column

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 behaviour 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.

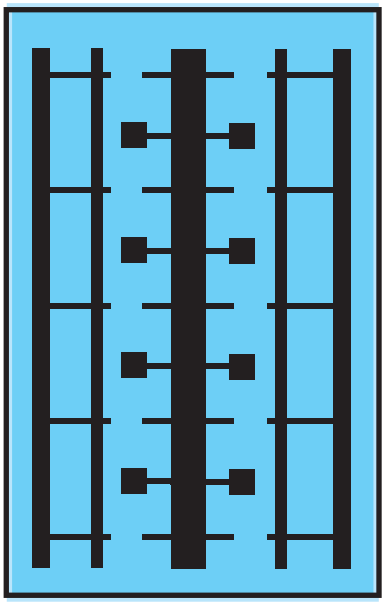
Diagram: Comparison of different free cross-sectional diameters of baffle-plates



AGITATED EXTRACTION COLUMNS

EXTRACTION COLUMN TYPE AME

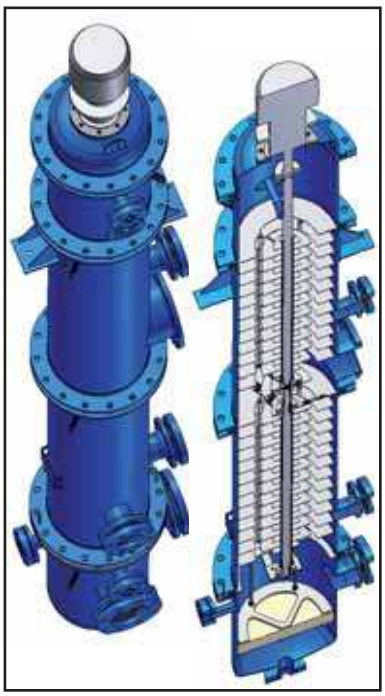
STANDARD TYPE EXECUTION FOR UNIVERSAL USE



Type designation
AME 500-30 S

500 Column diameter mm
30 Number of agitation compartments

F Flanged apparatus body
S Self-standing column
G Glass mantle



CAD-model type AMES 400-24

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

Predefined product properties and operating conditions

- Products composition
- Capacities
- Densities
- Viscosities
- Interfacial tension

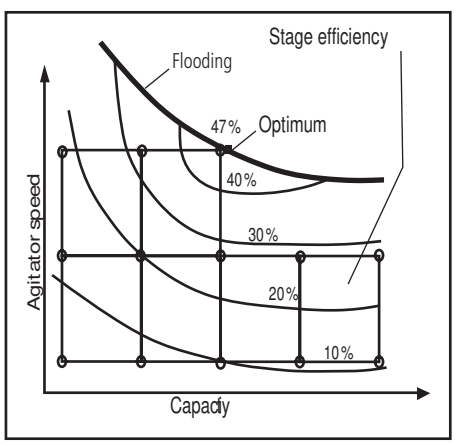
Adaptable column geometry

- column diameter
- free cross-sectional area of compartment separating plates
- compartment height
- agitator diameter
- agitator blade height

Adaptable operational parameters

- agitator speed
- temperature

Diagram: Dependency between agitator speed and capacity



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

Agitator shaft sealing
Construction of the shaft seal as double mechanical seal with adjacent seal liquid unit.

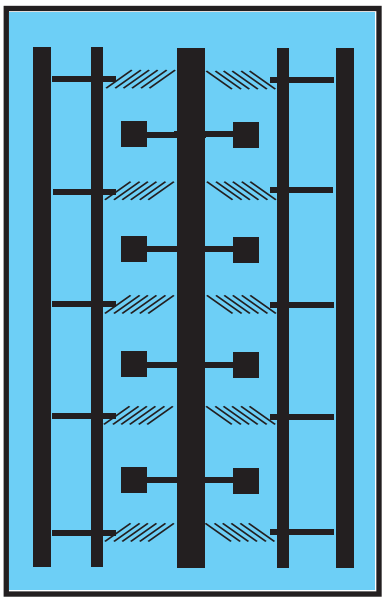
Inner bearing
Standard in hard metal SiC/WoC

Agitation unit of extraction column

AGITATED EXTRACTION COLUMNS

EXTRACTION COLUMN TYPE AMEX

COMPARTMENT GEOMETRY ADJUSTABLE DURING OPERATION



Type designation
AMEX 500-30 S

500 Column diameter mm
30 Number of agitation compartments

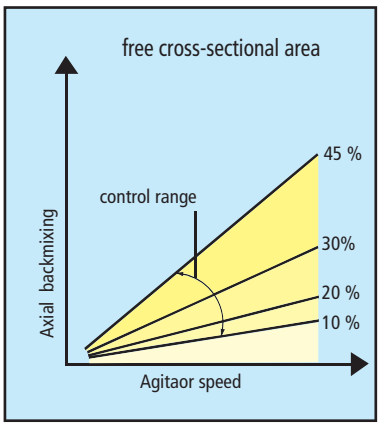
F Flanged apparatus body
S Self standing column
G Glass mantle

The possibility to adjust the compartment geometry (cross-sectional area) and the agitator speed (droplet size) as well gives an optimal and unparalleled flexibility. The optimal conditions are reflected by a certain retention of dispersed phase, measurable section by section (2 to 3 sections) by means of standard differential pressure cells (mean liquid density).

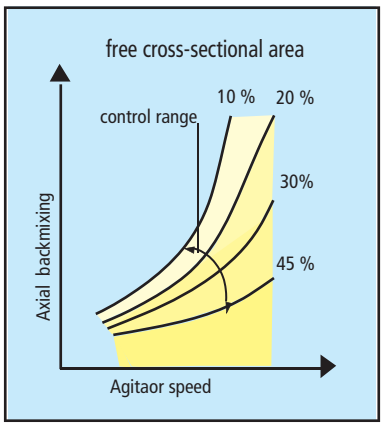
Advantages

- Maximum flexibility regarding capacity and process requirements
- Variable free cross-sectional area and variable agitator speed allows fine-tuning
- Adaptable to changing process conditions

Effect of the free cross-sectional area to the axial mixing



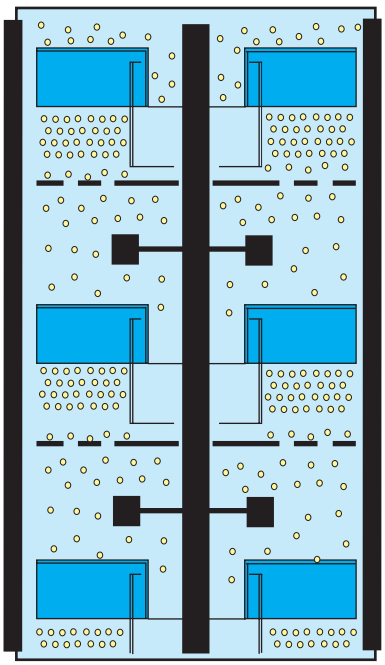
Effect of the free cross-sectional area to the mass transfer area



Dispersion of droplets in a liquid-liquid-extraction column

AGITATED EXTRACTION COLUMNS

MIXER-SETTLER-COLUMN TYPE MSCX



Type designation
MSCX 500-30 S

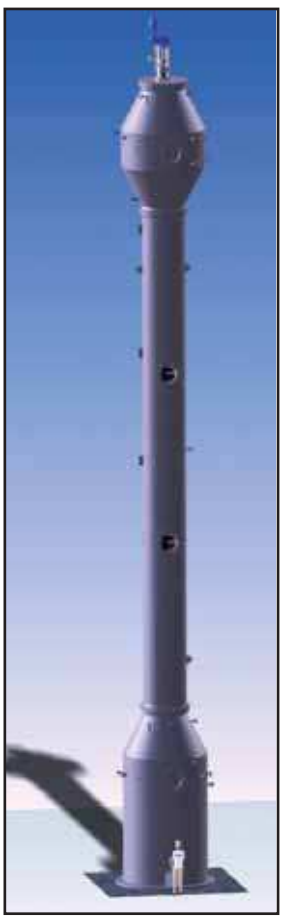
500 Column diameter mm
30 Number of agitation compartments

F Flanged apparatus body
S Self-standing column
G Glass mantle

The mixer-settler column corresponds functionally to 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 one unique drive unit.
As in a normal mixer-settler, there is a complete decantation of the two phases in each stage

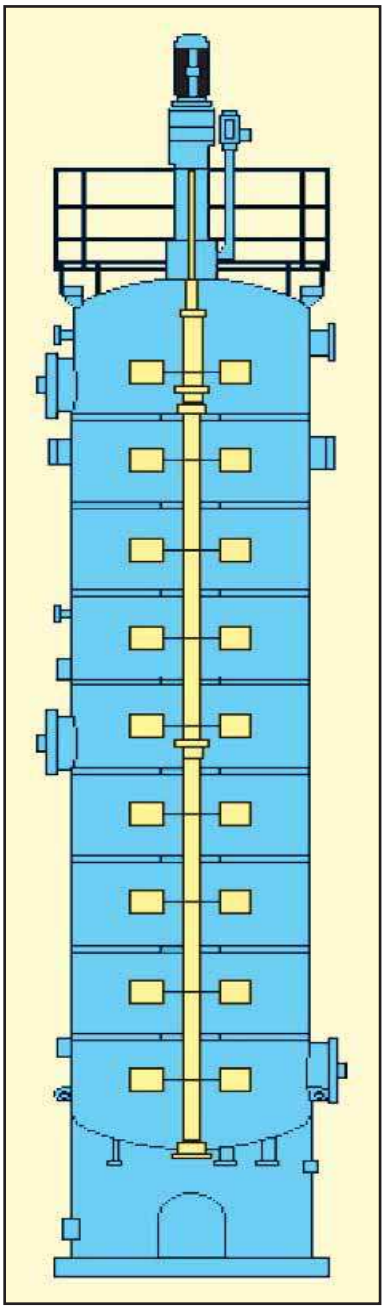
Preferential applications:

- Extraction systems with extremely slow mass transfer, often guided by a parallel reaction (e.g. metal extractions)
- Extreme phase ratios (e.g. 1:50)



MULTI COMPARTMENT REACTOR COLUMN TYPE MCR

- Suitable for carrying out homogeneous and heterogeneous (2-phase) reactions
- Corresponds functionally to a stirring vessel cascade



TESTING COLUMNS

EXTRACTION COLUMNS WITH GLASS MANTLE FOR LABORATORY, PILOT TESTS AND PRODUCTION

During tests, the observation of the flow phenomena is particularly important, so a glass mantle is inevitable. All glass parts meet QVF standards (borosilicate glass). Other norms are deliverable.

Internal parts made of

Stainless Steel, Hastelloy, Titanium, Zirconium, Tantalum, PTFE/glass fiber, PVDA, Plastic, Plastic-coated

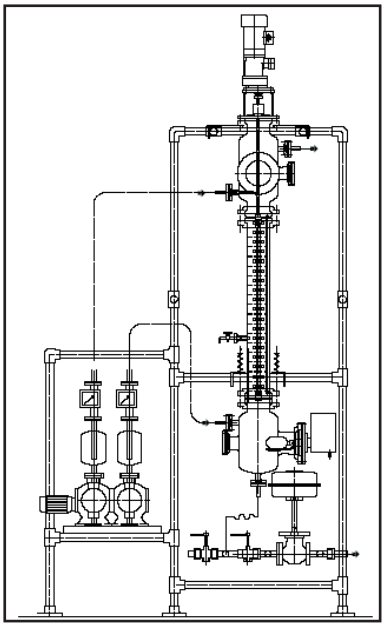
Type designation

TYPE AME 500-30 G

500 Column diameter mm
30 Number of agitation compartments
G Glass mantle

MODULAR TEST COLUMNS

- **Column diameter**
  All usual diameters: from DN50 up to DN1000



Rental extraction column DN150 with glass mantle/internals SS 316L

- **Modular construction**
  Exclusively testing columns DN50, DN80, DN100 and DN150
  Column length is variable, can be freely modified by assembling the column sections with 10 agitated compartments each.

Pilot column for rent

Since pilot tests always require large quantities of product, it is often preferable to do the testing at the customer's site, where the required product quantities are available, and even more importantly, where the produced extract and raffinate streams can be recycled or treated in some way.
We provide test columns DN150 or complete units with pumps, flow meters, interface control, agitator speed control, etc. to our customers on a rental basis.

Testing column Type AME 150-40 G

Testing columns with glass mantle standard sizes						
Column diameter		DN	50	80	100	150
Decanter diameter		DN	100	150	200	300
No. of agitated compartments/module			10	10	10	10
Module section height		mm	400	500	600	600
Total height with drive	1 module	mm	1600	1900	2100	2800
	2 modules	mm	2000	2400	2700	3400
	3 modules	mm	2400	2900	3300	4000
Drive motor Eex dll T4 400 V		kW	0,18	0,18	0,35	0,55
Speed range, max.		1/min	800	530	480	300
Total capacity approx.*	R=15 %	l/h	4	12	30	60
	R=50 %	l/h	30	120	200	500

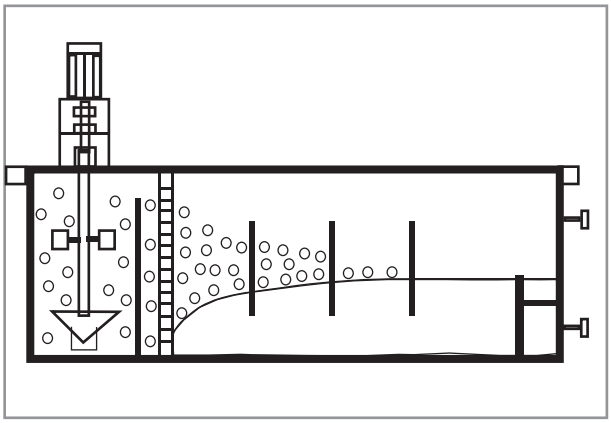
*) strongly depending on products

MIXER - SETTLER

MISCELLANEOUS CONSTRUCTION DESIGN

- Compact, space-saving design
- Single stage or batteries

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.



Type designation
MSB 150 - 3 G

150 Total volume 1500 l
3 Stages (batterie)
G Glass

Types and materials

Type MSB	Box design Single stage or multi stage Batterie materials: all weldable metals, plastics, plastic/GFR
Type MST	Tube design especially for glass and enamelled steel, metallic materials for higher operational pressures
Type MSV	Vessel type single stage or max. 4 stages suitable for higher operation pressures

Mixer-settler type MST 300

Pump-mix-turbine from mixer-settler type MST 300

3-stage mixer-settler type MSV 250-3 in SS

EXTRACT AND RAFFINATE TREATMENT

SCHULZ+PARTNER DESIGNS, DELIVERS AND BUILDS PLANTS FOR THE EXTRACT- AND RAFFINATE TREATMENT

After the extraction process further processing steps are required for solvant recovery and extract purification.

In a normal extraction process, both leaving phases need treatment, the extract and raffinate. The extract phase often includes an additional washing step before proceeding to the regeneration part, mostly a rectification column, where the solvent is separated from the extracted product and recycled back to the extraction column.

In the other phase, the raffinate always contains small quantities of solvent, so that a follow-up processing becomes necessary here as well.

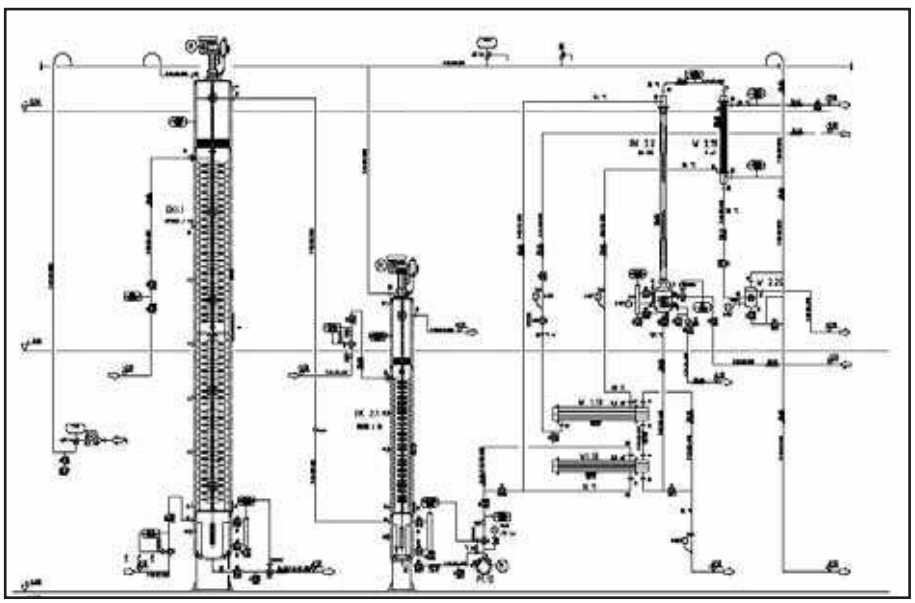
As the solvent is recycled constantly, there is a risk of accumulation of impurities, which occurs often. After a certain time, these impurities may interfere with the extraction process. Therefore, it is good practice to treat a small part of the solvent continuously through a cleaning step.

In other words, the planning of an extraction plant requires a good deal of experience, even more than for other plants. Schulz+Partner has the experience, owing to the large number of extraction units that the company has carried out.

In general, investment costs as well as energy requirements for the regeneration part of an extraction plant are higher than for the effective extraction part. But usually, the investment in our thermal processing plants redeems itself within a few month.

Rectification plant with thin film evaporator for solvent regeneration

P+I -Diagram of a liquid-liquid-extraction plant incl. re-extraction



Agitation reactor

PLANT CONSTRUCTION

COMPLETE PLANTS PROCESS UNITS AND PRE-ASSEMBLED SKID UNITS

- Calculation and design of the entire plant, with guaranteed performance
- Basic engineering
- Detail engineering
- P+I - Diagram
- Installation planning
- Procurement of materials
- Electric planning
- Erection supervision
- Commissioning
- Staff instruction
- After-sales-services

Rectification plant

Control cabinet

Plant construction

Liquid-liquid-extraction with solvent recovery

Transport of a pre-assembled skid-unit

FIELDS OF ACTIVITY

ENGINEERING
- Consulting
- Laboratory/pilot testing
- Process development
- Process simulation
- Project evaluation
- Basic- and detail engineering
- Installation planning 3D
- Measuring and control engineering
- Automation, Procurement of materials
- Assembling and supervision, startup
- Operators instruction

PLANT CONSTRUCTION
- Turn key plants
- Complete process units
- Premounted skid-units
- Plant equipments

MAINTENANCE
- Service contracts for all delivered plants and external plants, especially for heat pump units

EVAPORATION
- Heat pump evaporators
- Natural/forced circulation evaporators
- Falling film evaporators
- Evaporators with vapour compression
- Thin film evaporators
- Short path evaporators

CRYSTALLISATION
- Evaporation crystallisers
- Cooling crystallisers

DRYING
- Thin film dryers,'Combi'dryers
- Heat pump dryers (batch mode)

RECTIFICATION - ABSORPTION
- Rectification columns
- Trays and structured packings
- Absorption columns

LIQUID-LIQUID-EXTRACTION
- Extraction columns, agitated and pulsed
- Mixer-Settlers
- Multistage reaction columns

- 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