Columns and mixer-settler for the liquid-liquid-extraction

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The technical complexity for extraction procedures is generally quite great because at normal case, both discharged phases extract and raffinate demand an additional separation stage. The extracting agent is regenerated from the extract and returned to the extraction in the circulation. The raffinate – often wastewater – contains more or less extracting agent that also has to be separated from it. Usually, the actual extraction part requires only the smallest part of the installation costs.

Test and design

The calculation of extraction columns with computer simulation – as it is generally exercised with good results in rectification processes – is only partly working in liquid-liquid extraction. Practical experience shows that theoretically calculated concentrations of both phases often greatly differ from the experimentally ascertained numbers.
This might be a consequence of the use of complex mixtures and the fact that even only a slight contamination might affect the result.
Furthermore, the reciprocal activity coefficients required for a reliable calculation are unknown in most cases.
Even today, lab experiments are essential when a reliable solution is needed. Unfortunately, due to the unavailability of the original substance, synthetic mixes have to be used often.
The calculative acquisition of the hydrodynamic conditions for dimensioning the extraction column is also only conditionally possible; more experimental work is necessary for a definite dimensioning.
Generally, the necessary experimental work for a new process work is divided in two stages.

a) Appraisal or confirmation of the adequate extraction substance; ascertainment of the phase equilibrium for the whole concentration area of interest.
A continuous, multi-stage lab equilibrium apparatus (6-10 agitator stages with an efficiency factor of up to 95%) can be helpful, because the number of the necessary separation stages is given as well as the effective volume ratio and the data on chemical media.

b) Lab or pilot experiments with an adequate apparatus that deliver the basics for the scale-up for an industrial plant.

It is necessary to note that the hydrodynamic conditions in smaller lab columns differ greatly from those in bigger/larger industry columns and therefore cannot be transferred one-to-one/exactly. Similar behaviour can be assumed with the column type "Künzi" AME for pilot column diameters starting at 150mm, whereas according to experience, a certain safety buffer is planned in a direct transfer (similar column geometry, identical specific throughput, identical number of agitator stages).

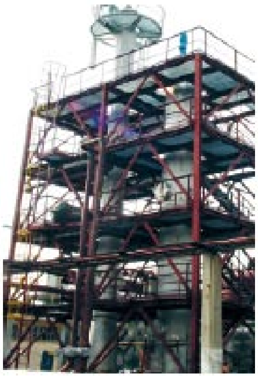

Fig. 1. Extraction plant Rompetrol Vega Refinery, Ploiesti/Romania.

Embodiments

There is a great number of embodiments: packings, perforated tray, with or without pulsation, stirred columns with different agitator stage constructions. In lab standard (yardstick; engin.), practically all systems work satisfyingly. However, for larger industry apparatus, the stirred column proved itself to be the only universally applicable apparatus. Stirred systems have the advantage that the hydrodynamic conditions can be transferred to great units thanks to clear transfer regularities. They work properly even with heavy solid-loaded media. In contrast to that, packages and perforated trays are very easily soiled. However, out of lack of knowledge, large pulsed packing and perforated tray columns are implemented even today.
Their efficiency decreases with increasing diameter because of the correspondingly higher energy demand and because the required high pulse repetition frequency cannot be adhered to due to the great mass (ca. 1000kg for a column diameter of 500mm).
Static packing columns (without pulsation) also deliver a poor separation output, as the required mass transfer face is inexistent because of the insufficient drop dispersion.

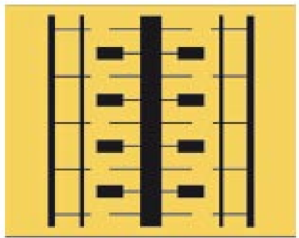

Fig. 2. Scheme
Extraction plant type „Künzi" AME.

Stirred extraction column type "Künzi" AME

The basic configuration of a stirred extraction column is shown in fig. 2. The column shows all desirable characteristics of an optimal column construction:

- mechanically simple/functional design, correspondingly cost-efficient, safe in operation and with minimal maintenance charges
- low agitator speed (30upm for column diameter of 1000mm) guarantees robustness and minimal energy input
- Variable stage geometry allows adaptation of the dimensions to the material system. According to requirements, the agitator stage geometry can be dimensioned/designed especially for a great throughput or a high separation stage number. Often, process conditions are changed subsequently. Errors in design (e.g. when no or only limited tests were possible) can be corrected as well. With a simple replacement of the stage-limiting pressure plates with different diameter, the column can be retrimmed to optimal capacity.
- Insensitive to solids and dirt
- Applicable for small pilot columns as well as large columns with a few 100'000m³ throughput.

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- Clear and sound design and scale-up concept: drop-size, stage circulation mass and axial backmixing are the decisive design dimensions that are kept constant in the enlargement according to known principles and correspondingly adjusted agitator and stage geometry.

Stirred extraction column type "Künzi" AMEX

The basic configuration of this column type is identical to the afore described type "Künzi" AME except for the possibility of mechanically adjusting the pressure plate cross-section in sections without operational break. Combined with a differential pressure measurement, this allows an optimal adjustment of the Drop-Hold-up over the entire column height with a simultaneous minimization of the axial backmixing.

Mixer-settler type KMS

The basic configuration is shown in fig. 3. In contrast to extraction columns, the both mixed stages are entirely decanted with mixer-settlers. Thus, the required total volume is much greater with mixer-settlers than with columns. Instead, the axial backmixing is omitted despite mostly much more intensive agitation and the stage efficiency normally amounts up to 100%. Hauling from stage to stage requires according to phase and density conditions a special agitator in form of an impeller ("pump-mix").

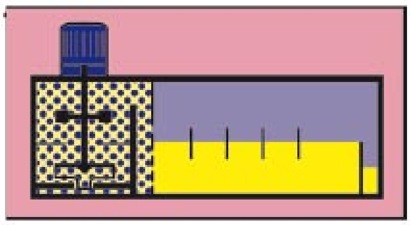

Fig. 3. Scheme Mixer-Settler type KMSB.

Characteristic features of the mixer-settler type KMS are:

- mixer is subdivided in 2 to 3 stages, central shaft with several stages (one thereof optionally pump-mix). The excess chamber construction altogether/collectively effects a higher resulting concentration gradient and does therefore need correspondingly less mass transfer face. Thus, it can be operated with bigger drops (reduced rotational speed) and under avoidance of micro-fractions that are very disadvantageous for the following decantation. The total stage volume can be slashed according to sensitivity of the material system to build emulsions.
- Mixer-settler of type "KMS" are airtight and entirely water-filled, thus no vortex formation in the mixer possible
- Settler with baffles for controlling and unification of the holding time

Embodiments

- type KMSB: box-shaped with rectangular profile/cross section, single stage or battery with various number of abreast arranged packages/items; materials: all weldable metals, synthetics or synthetic compounds, C-steel with lining/coating
- type KMST: tubular, single stages, battery with interconnection lying outside; materials: glass, C-steel enamelled, C-steel with lining/coating, metals
- type MSV: stirred tank shaped, single stage up to max. 3 stages per apparatus; materials: all weldable metals, C-steel with lining/coating

Reaction mixer-settler type RMS

Metal salt extractions like the industrial winning of copper with D(2)EPHA/kerosene, are based on the combination of extraction and reaction (complexation). The mass transfer is controlled by the slow reaction kinetics, which means that the mass transfer from phase to phase runs according to process 10 to 1000 times more slowly than with a normal extraction.

The type KRS consists of a large-volume mixer in form of a reaction column that is subdivided in 6 agitator stages for achieving a perfectly continuous current with consistent resting time and a gradual concentration-decline. Thanks to the moderate agitation intensity with avoidance of micro fractions and of formation of emulsion, a relatively small settler, that is arranged at the head and the base, will suffice.

Several chunks are united to a countercurrent battery whereas the advancement / extraction of the dispersive stage requires a pump/mix agitator or an outside lying pump in the following stages.

Advantages are:

- a considerably smaller total volume of the mixer-settler battery compared to conventional plants
- altogether reduced agitation energy input