TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Institut für Verfahrenstechnik, Umwelttechnik
und Technische Biowissenschaften
Getreidemarkt 9/166, 1060 Wien, Österreich
Tel.: +43 1 58801 16600
sekretariat+E166@tuwien.ac.at
www.vt.tuwien.ac.at

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Concentration of valuables from aqueous product solutions

The concentration of product solutions in the food industry, chemical industry and pharmaceutical industry is often performed using thermal processes. The solvent, water, is typically evaporated in a multi-stage evaporation process at temperatures of up to 130°C until the desired residual content is achieved. In spite of improvements, the technology remains highly energy-intensive and linked to high thermal loads on product materials.

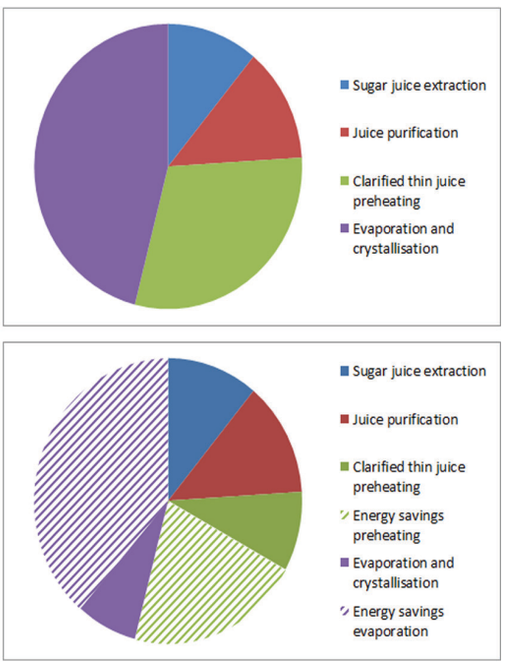
Objective

The aim of the research conducted by the work group led by Professor Harasek in the area of „Thermal Process Engineering & Simulation" at TU Wien was to develop alternatives to the conventional evaporation process with significantly lower energy requirements. The procedure must be able to be used for a wide range of concentrations and should be based on industrially available components, in order not to be tied to one or a few component suppliers.

Approach

The use of the membrane separation process of reverse osmosis or nanofiltration for the concentration of product solutions, such as sugar solutions, fruit juices, lactic acid and amino acid solutions is well known. However, due to the high osmotic pressure and high viscosities, limits are quickly reached for these processes. The idea of the research team was to develop a multi-stage membrane process – from a combination of reverse osmosis and at least two nanofiltration stages.
In this process, membranes with lower retention capacities are deliberately used, so that the osmotic pressure difference can be controlled very precisely at every stage and lower process operating pressures of as low as 40 bar are sufficient.
With intelligent recovery of the separated flows of recyclable materials into the upstream process steps, loss of valuable material is minimised. Water is only discharged in the reverse osmosis stage. As a result of the low process temperature – in comparison to the evaporation method – product quality increases. The number of stages can be adapted depending on the requirements for the concentration.

Three-stage pilot system (RO/NF/NF) with five 4" membrane modules



Example of the energy savings in thin sugar juice concentration: conventional and TU Wien process

Results

The team of researchers has already demonstrated it developement in a three-stage reverse osmosis/nanofiltration system. The pilot system is fully automated and can be used at operating pressures of up to 60 bar and temperatures of up to 80°C. Comprehensive test results are already available for the concentration of diluted sugar syrup with a wide range of different membrane combinations. The prototype successfully confirmed energy savings of over 50% compared to the conventional multi-stage evaporation process.

Benefits for you

There are no particular restrictions on the selection of the product material to be separated in the process designed by TU Wien. Here, sugar solutions or fruit juice, or solutions of lactic acid or a salt thereof, amino acid solutions or other aqueous, non-aqueous or mixed aqueous/non-aqueous solutions can be used, as for example occur in the chemical, pharmaceutical and biotechnology industries. This technology is particularly suitable as a pre-concentration step in conventional evaporation processes – for example in the sugar industry – or anywhere conventional pressure-driven membrane separation processes are used.

The advantages of the process are:

- Reduction of more than 50% in the thermal energy requirement for the evaporation
- Operation also possible with high concentrations of product materials and viscous media
- Multi-stage reverse osmosis/nanofiltration process instead of conventional evaporation
- Higher energy efficiency and lower operating pressures than conventional membrane methods thanks to intelligent process circuit
- Integrability/Debottlenecking of existing systems
- Simple scale-up based on data
- Fully automated demonstration system with approx. 50 m² of installed membrane surface area ready for use in the technical centre for customer tests
- Several months of operational experience already shown with the demonstration system
- Design model for estimation of energy savings

Point of contact:

Ass.Prof. Dr. Michael Harasek
TU Wien - Institute of Chemical Engineering
P: +43 1 58801 166202
M: +43 664 6104922
michael.harasek@tuwien.ac.at
www.membran.at