ECCE 10 + ECAB 3 + EPIC 5

September 27th October 1st, 2015 - Nice, France

Round Table discussion

Industrial Use of Thermodynamics ;   Energy: conservation and Management

Thermodynamic Analysis Methods for Process Energy Systems Engineering

Tuesday September 29th, 11:30am-1:00pm, Méditerranée 4

Chemical Engineering is a profession where both a global systems approach is needed and a detailed understanding of the underlying physics. Integrating these two scales requires a combined expertise and a common language for communication between experts of different fields. Yet, we too often observe that the same words have different meanings, depending of the community we are in. In view of improving cross-competence communication, the EFCE Working Party on Thermodynamics and Transport Properties and the managerial team for the topic on “Energy: resources, conservation and management” invite you to **share your vision on the appropriate role of Systems Engineering and of Thermodynamic Analysis in the energy improvement of unit operations and systems**.

- What does “thermodynamic analysis” or “energy optimization” mean in my context?
- What are the obstacles inhibiting collaborative efforts for innovation?
- How can improving knowledge in my field help improving the other fields?

Distillation, one of the most energy intensive separation technology, is a perfect example (yet not the only one!). How should this technology be further improved: : through a better understanding of properties (transport, transfer, equilibrium) or improved equipment design ?

With an introduction by Dr. Jean-Charles de Hemptinne (IFPEN) and the contribution of:

- Prof. Andrzej Gorak (TU Dortmund), moderator
- Prof. François Maréchal (EPF Lausanne)
- Dr. Olivier Baudouin (ProSim)
- Prof. Michel Meyer (ENSIACET)
- Prof. Signe Kjelstrup (NTNU)
- Prof. Rafiq Gani (DTU)

The Future of Distillation – Industries' Most Energy-Intense Technology

The Science Symposium "Smart Energy for a sustainable future" March 9-10 is all about the importance of new energy technologies. On Creator Space Online, Professor Andrzej Górak, takes a close look at the most common and most energy-intensive separation technique: distillation. It is used in refining crude oil or the manufacture and purification of nitrogen, oxygen and other gases. Górak leads the Laboratory of Fluid Separations at the Department of Biochemical and Chemical Engineering at the Technical University of Dortmund, Germany, and has edited the most comprehensive work on distillation ever published: Distillation: Fundamentals and Principles [1]. Join him in discussing opportunities on how to improve the energy consumption and efficiency of distillation.

Ancient But Still Interesting

For more than 5,000 years distillation has been used as a method for separating binary and multicomponent liquid mixtures into pure components. Even today, it is amongst the most commonly applied separation technologies and is used on such a large scale worldwide that it is responsible for up to 50 % of both capital and operating costs in industrial processes. It absorbs about 50 % of the total process energy used by the chemical and petroleum refining industries every year.

Distillation seems to be a mature technology, but it will continue to interest researchers and practitioners for the next decades because of its significant practical relevance as well as unsolved questions such as how to substantially reduce the energy footprint of chemical processing.

Current and Future Trends

Distillation columns – large cylindrical columns packed with trays, plates, or packing material to allow better contact between two phases – are typically used for industrial distillation. During the last twelve years, the column internals have been continuously and substantially improved by equipment providers. These include, for example, the Raschig Super-Ring [2], sandwich packing [3], and high performance distillation trays [4].

Academia has developed very sophisticated mathematical tools for conceptual distillation design. Many of these tools have been adopted by end users in the chemical and petrochemical industries and open new pathways for identifying optimal separation schemes, process modelling, and optimization.

Reactive distillation, which is the simultaneous realization of a chemical reaction and a distillative separation, has also been improved extensively. Today it is possible to recover carboxylic acids produced by fermentation [5] or to separate chiral substances using enzymatic bioreactive distillation [6]. However, for bioproduct processing in particular, reactive distillation still needs further study.

The big challenge, however, is the development of mega-equipment and better integration of distillation with other unit operations such as pervaporation (a membrane process for the purification of liquid mixtures), vapour permeation, organic solvent nanofiltration, and extraction [7]. For this, more detailed models and design tools are needed that can handle multicomponent and multireaction systems as well as manage the complexity that comes with the large number of potential process configurations and large sets of potential solvent–membrane candidates.

Smart Use of Energy

Given that the chemical industry consumed 19 % of the energy in Europe in 2009, distillation is clearly a significant driver of overall energy consumption. We need to reduce its energy consumption through

- further improvement of the overall performance of column internals;
- use of better solvents for extractive or azeotropic distillation;
- placement of several distillation columns in one shell (divided wall columns);
- integration of distillation with other separations such as reactive agents, adsorbents, and membranes.

Alternative energy sources such as microwave, plasma, ultrasound, electric fields, and light have the potential to improve chemical syntheses in terms of energy and resource efficiency. Currently, practical applications of alternative energy sources such as microwaves are far from ready for application in distillation. Ultrasound can be used to increase the mass-transfer area rather than as a source for energy input. Fundamental research is needed here and is being carried out as part of some European and national projects. One of them is the European research project Alternative Energy Forms for Green Chemistry (*ALTEREGO)* [8]. It aims to develop new methods to use alternative energy technologies in processes for advanced pharmaceutical synthesis, green fuels, and bulk chemicals synthesis.

References

[1] *Distillation: Fundamentals and Principles* (Eds: Andrzej Gorak, Sorensen),

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[3] N. Kashani, M. Siegert, T. Sirch, *Chem. Eng. Technol.* **2005**, *28*, 549–552. DOI: 10.1002/ceat.200407153

[4] T. Cai, M. Resetarits, A. Y. Ogundeji, T, *Core Programming Area at the 2014 AIChE Spring Meeting and 10th Global Congress on Process Safety* **2014**, 482–488.

[5] C. S. López-Garzón, A. J. J. Straathof, *Biotechnol. Adv.* **2014**, *32 (5)*, 873–904. DOI: 10.1016/j.biotechadv.2014.04.002

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[8] Alternative Energy Forms for Green Chemistry (*ALTEREGO*), *www.alterego-project.eu/*