ECN

Energy research Centre of the Netherlands

Process intensification

Background

Energy research Centre of the Netherlands at Petten is an independent market-oriented organisation for research, development, consultancy and knowledge transfer in energy-related fields. ECN develops sustainable technologies and is engaged in work on solar, wind and bio-mass energy, fossil fuels, energy efficiency and policy studies.

In recent decades there has been a significant increase in the energy efficiency of the process industry by optimisation of unit operations. In many cases the limits of what can be done on a unit-operation scale have been reached. To maintain the trend of increasing energy efficiency, it will be necessary to concentrate the various physical steps and chemical reactions into a single process step that makes only the desired product. For this purpose, new technologies are needed that fundamentally and radically change the industrial processes. This combination of unit operations is called process intensification.

What is process intensification?

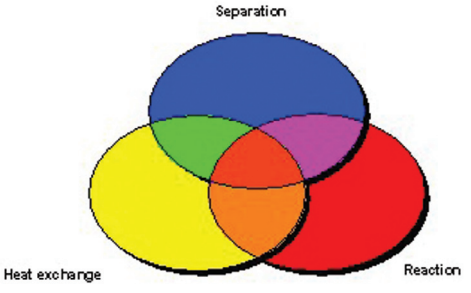
In many chemical production processes, reactions are limited by physics. Reaction rates are often reduced by slow mass transfer of reactants to the reaction, bad heat supply to or removal from the reaction and build-up of products. The design of the unit, rather than the chemistry itself, is the limitation.

Process intensification aims at designing reactors in such a way that these barriers become (orders of magnitude) smaller. More compact units, lower investment cost, higher yields and reduced energy cost result from this. One of the most powerful process intensification methods is combining two or more classical units into one hybrid unit.

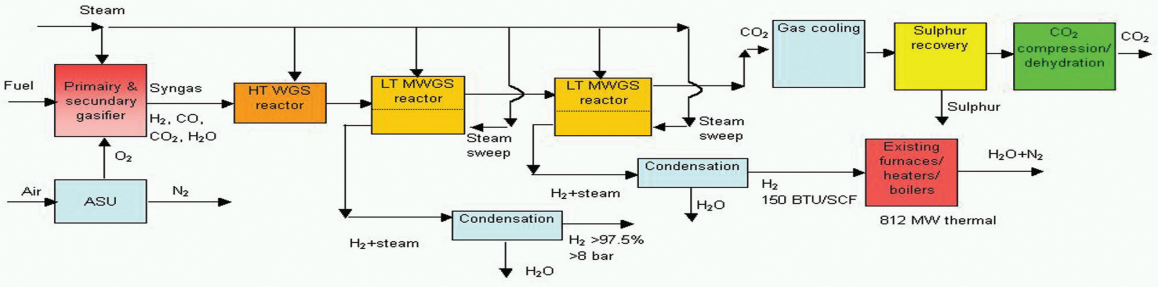
General examples

In the figure examples are given for three unit operations that are often used in the chemical industry. Examples of combinations are:

- Reaction-separation: Membrane reactors, reactive distillation.
- Reaction-heat exchange: HEX-reactor.
- Separation-heat exchange: Dephlegmators or heat integrated distillation.
- Reaction-separation-heat exchange: Isothermal membrane reactor.



Examples of a combination of unit operations in process intensification.



Example of membrane reactor flowsheet for hydrogen production and CO_2 emission reduction.

ECN Energy Efficiency in Industry

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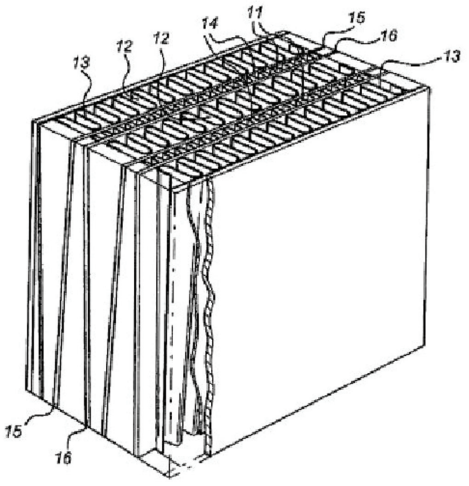


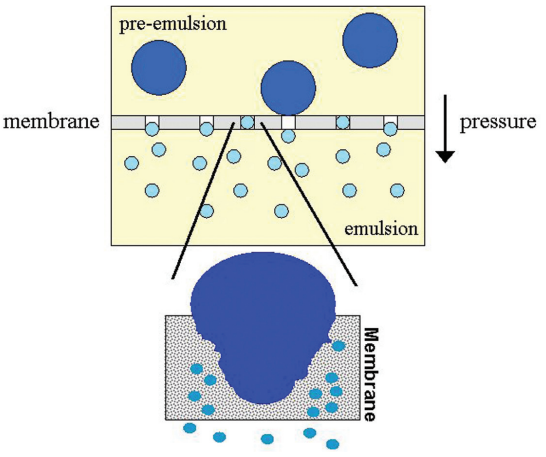
ECN's patented plate-fin heat exchanger concept that can be used in a Heat Integrated Distillation Column (HIDIC).

R&D programme at ECN

- Membrane reactors in which the reaction is combined with separation of the reaction product from the reaction zone. Advantages can be very high when this is used for shifting the equilibrium of reactions such as dehydrogenation, steam reforming, esterification reactions, or ammonia synthesis.

Show model of a membrane reactor for hydrogen separation during steam reforming.

- Membrane contactors, where reactants are fed in a controlled way to a reaction, leading to a higher quality of the desired product with lower amounts of by-products. Application of membrane contactors is foreseen in the field of partial oxidation reactions.
- Membrane emulsification. High-value emulsions can be made via a porous structure in which very well controlled local and highly intensified shear rates can be obtained, leading to a process with much lower energy use and more homogeneous emulsions than the conventional high-speed high-pressure mixers.



Examples of emulsion droplet formation via a porous membrane.

Clients, co-operation partners and financiers are originating from major process industries, small and medium enterprises, European Union, national and local governments, universities and research institutes.

Interested in an energetic and challenging technology venture with us:

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