How Does Process Intensification Play a Role in Energy Production?

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Traditionally, conservative chemical processes are usually developed, designed, and operated under steady state condition. Whatever the process improvements are performed, the new designs are still based on the steady state values. As a consequence, the achievement of the process performance becomes locked in a certain region due to limited domain of process variable. Since the steady state operation is designed at certain time scale, its achievement becomes fixed at certain operating condition. Process intensification is another window of operation in which the process variables are creatively and innovatively developed according not only spatial domain, but also time domain. A set of often radically innovative principles ("paradigm shift") in process and equipment design, which can bring significant benefits in terms of process and chain efficiency, capital and operating expenses, quality, wastes, process safety, etc. are point of view in the process intensification. It means the exploration of better process performance is always open to gain in a wide range of operating window. This is obviously in line with efforts for increased competitiveness in chemical engineering modernization. New challenge in process design and operation is the investigation to determine the proper dimension and time scale under dynamic operation. These design and operation have opened a new way in process intensification for increased process performance if dedicated design and operation procedure can be developed.

In this lecture, the development of microreactor for hydrogen production, dynamic operation advantage of a reverse flow reactor for converting waste to energy, and Pd based membrane for hydrogen separation are presented. The operation focuses on the influence of the reactor design and switching time of the dynamic operation, either by reversing the flow direction or by modulating the feed gas. The steady state condition is used as a base case for comparing the performance gained in the unsteady state operation. Interesting applications is for energy production will be discussed in such creative and innovative manners as shown in Figure 1.

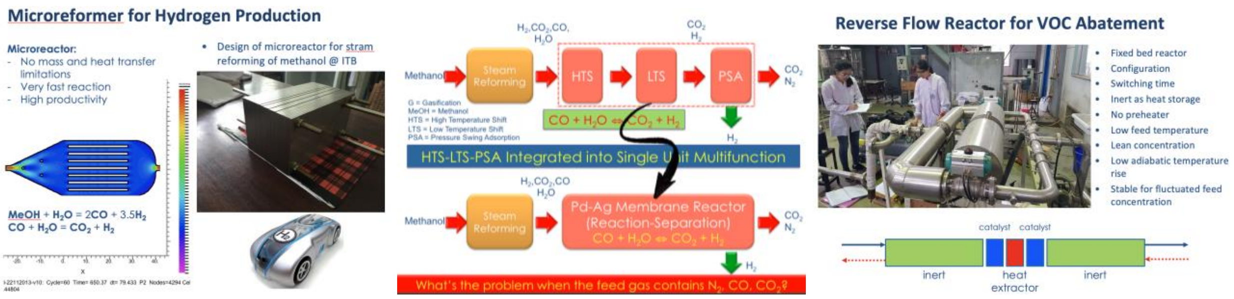

Figure 1. Microreactor for hydrogen production, process integration of HTS-LTS-PSA into a single unit of membrane reactor for hydrogen separation, and pilot reactor of flow reversal.

In the microreactor for hydrogen production, the productivity can be increased more than 6000 than in the fixed bed reactor. In the dynamic operation of the Pd-Ag membrane, we have improved the time period during start-up and the membrane stability. In the reverse flow reactor, significant conversion of gas emission can be abated by authothermal reactor.

Keywords: Hydrogen; Membrane; Process intensification; Steady state; Unsteady state reactor