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Moshe Sheintuch, Olga Nekhamkina

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Architecture Alternatives for Propane Dehydrogenation in a Membrane Reactor

Moshe Sheintuch* and Olga Nekhamkina

Dept of Chemical Engineering, Technion, Haifa, Israel 32000.

Abstract

The main factors affecting the design of a Propane Dehydrogenation Membrane Reactor (PDH MR) are the deactivation of the catalyst and of the membrane due to coking. Both apparently accelerate with increasing temperature or pressure and with depletion of hydrogen; i.e., with conditions that improve conversion in a membrane reactor. Recent studies of this project [2 - 3] suggest that pressure should be kept below 5 bar and catalyst temperature should be around 450-500 C, while the membrane should be kept at 200- 250C to avoid coking. This favors the distributed reactor design (open architecture) which requires as many as 6 pairs of reactor-separators to achieve the desired 25% conversion with very high sweep to feed ratio (3 for each unit or 18 overall) compared with a single integrated MR that can achieve the same conversion at 450C with sweep/feed ratio of 2 or more with counter-current flow. Both designs will yield good selectivity but the catalyst life time is predicted to be ~2 days while the membrane life time will be shorter in the integrated design as opposed to a stable activity in a cool (250C) separator.

A new integrated design with an internal gradient is suggested combining the advantages of both approaches. It is based on a three cylindrical zones reactor with catalyst in the outer layer, maintained at 450C, permeate in the inner with sweep fed at 250C, separated by an inert insolating layer. Initial calculations showed promising results.