NOVEL APROACH TO PROCESS SYNTHESIS BASED ON DYNAMIC OPTIMIZATION AND EXPLOITION OF PROCESS INTENSIFICATION PRINCIPLES

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Traditionally, process synthesis consists of three consecutive phases: i) selection of the operation mode (continuous or batch), ii) process design; iii) control conceptual design. Although this methodology is well established in practice, it is largely based on heuristics, it does not allow the interaction of design and control and therefore it is usually suboptimal from both economic and control standpoint.

A new approach to process synthesis, based on dynamic optimization, is going to be presented and illustrated on examples. In contrast to traditional approach this concept provides strong interactions between operation, design and control. Optimization objectives are economical and optimization results provide optimal solution regarding both process design and operation. Proposed synthesis concept is determined by optimal manipulation of fluxes and driving forces within a process. Therefore it promotes the exploitation of process intensification principles and methods for process design. It also explores the possibilities for actuation improvement for optimal operation and control.

The basic concept is illustrated on two examples. The first is a complex exothermic reaction system from fine chemical industry. The second case is industrially relevant gas phase catalytic reaction – methane steam reforming accompanied with water gas shift reaction. The dynamic models are simplified, depicting dominant physical and chemical phenomena, in order to attain convergence during the optimizations with a number of control variables and constraints. For both examples, the goal is expressed as an economic objective function that involves revenues of the desired product, capital cost (depreciation) for the process and energy cost. Several reactor types (fedbatch, oscillatory baffled, helix, catalytic membrane) and ways of operation (optimal reactant feeding and optimal heat input, unsteady state) are subjected to dynamic optimizations in order to attain most profitable solution, while maintaining process constraints satisfied.