540d Design of Sustainable Chemical Processes:Systematic Retrofit Analysis and Generation & Evaluation of Alternatives

Ana I. C. S. G. Carvalho, Rafiqul Gani, and Henrique A. S. Matos

The competition on the chemical market has increased during the past decades and among the problems that the chemical and process industry have to face, the following can be mentioned: first, many chemical plants for the production of bulk products were built when profit margins could be kept large; second, past globalisation did not result in such a great competitive pressure as currently encountered by the operating companies. Therefore, to be still competitive, most existing production processes need to make constant improvements through retrofitting while new processes need to satisfy stricter governmental regulations with concerns to pollution and process safety. Increasing productivity, reduction of waste and energy consumption, reduction of valuable raw materials, recovery of products, and the last but not the least, the requirements related to process safety and process controllability, all represent conditions (or constraints), which can be formulated as mathematical optimisation problems. They also, together, formulate the conditions for a more sustainable process.The objective of this paper is to present a new generic and systematic methodology for identifying and screening the design (retrofit) potential of any chemical process. The methodology determines a series of mass and energy indicators, establishes the operational and design targets, applies a conflict resolution method to resolve the conflicts between the competing targets and their relation to the final design, and finally, obtains a design by matching the targets that improves the indicators. The significance of this new indicator-based method is that it is possible to direct all the contradicting criteria (factors) to move in the same direction, thereby eliminating the need to identify trade-off based solutions. For the same reasons the sustainable metrics move in the "desired" direction. That is, the environmental impact is reduced because less mass is released (in terms of emission) and because less energy is used, the global warming potential is reduced. Finally, the indicators also reduce (where feasible) the safety indicators because the conditions of operation become less extreme. The main features of the new indicator based method has been highlighted through different case studies, for example, the well known, HAD process and the process from the Eastman Kodak challenge problem. In this presentation a new case study involving the production of Methyl Tertiary Butyl Ether (MTBE) will be presented. Through the case study, the main features of the algorithm, such as the determination of the indicators, which will be the method targets, and the generation of retrofit alternatives, which will improve the process, will be illustrated. Finally, an analysis of the sustainability metrics will be presented for the case of large reservoir of raw materials and for not so large reservoirs. That is, is it counter productive to make a process sustainable if the raw material source is limited?