79f Optimal Economic Design and Operation of Single and Multi-Column Chromatographic Processes

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Chromatography is an increasingly important separation technique in the fine chemical, pharmaceutical and biotechnological industries. Over the years, the operation of the chromatographic process in these industries has developed rapidly and it is no longer limited to batch processing. Whilst the single column is still popular in preparative chromatography, multi-column processes, such as simulated moving bed (SMB) chromatography, are now becoming increasingly favoured in industrial-scale chromatography as a continuous alternative producing large amounts of highly purified products. As such, the decision of whether to use a single column or a multi-column process for a given separation is not clear cut. As the configurations and process operations of the two modes are vastly different, economics forms an integral part of the comparison. This work considers optimisation of the design and operation of both single and multi-column chromatographic processes taking into account both capital and operating costs. Such a detailed comparison has not been examined so far in the open literature.

Previous work comparing single column and multi-column chromatography has been based on comparing the two processes on specific outcomes such as eluent consumption or specific productivity (Nicoud et al., 1993; Grill et al., 2004). Such comparisons fail to consider underlying economic issues which may be in conflict, e.g. multi-column processes are associated with a high investment cost but have reduced eluent consumption, whilst single columns have lower investment costs but lower efficiency. As a result, these comparisons, whilst useful in highlighting the advantages and disadvantages of both systems relative to each other, do not provide any useful means of choosing between these systems. An economic comparison between the optimised process alternatives is thus necessary to properly assess the strengths and weaknesses of each system, particularly from an industrial point of view.

In this work, reliable and accurate chromatography models are used to describe single and multi-column chromatography processes whose design and operation are optimised simultaneously to maximise their individual annual profit. Thus, the decision variables considered include not only the configuration, but the design of the columns used, as well as the operating policy employed. In column chromatography, a single column, as well as a single column with recycle and peak shaving operations, are considered, whilst for the multi-column alternative, the SMB process and its variations (Varicol, Powerfeed etc.) are examined. In addition, the effects of employing different objective functions (e.g. maximum productivity or minimum separation costs) in the optimisation are assessed.

A detailed economic appraisal is performed of all process options. Case studies from different industrial sectors are used to illustrate the approach. The effects of considering different objective functions are highlighted and demonstrate the importance of making the correct function choice depending on the purpose of the optimisation.

References

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