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Utilisation of Column Profile Maps for the design and optimisation of complex distillation processes

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Abstract

A novel technique for computing the minimum reflux for multi-component conventional columns as well as complex configurations has been developed. The technique is a short cut, geometrical, non-iterative method. It predicts how the minimum reflux solution and hence the profile orientation is related to the feed-component distribution for all possible operating conditions and any number of components. The technique makes use of Column Profile Maps and the eigenvectors of the Jacobian matrix of the separation vector evaluated at the feed condition. An integral part of the method is the development of the feasible regions in composition space that restrict our choice of the product specification. The Column Profile Map-Eigenvector technique has shown to produce results exactly equivalent to those as predicted by the Underwood method.

To demonstrate the Column Profile Map-Eigenvector technique to complex configurations the method is employed in the detailed design of the Petlyuk Column. Although the overall column minimum reflux calculation is not shown, the application of the Column Profile Map-Eigenvector technique is utilised to determine the complete feasible operating region. The feasible column parameter region derived from the CPM-E technique is shown to encompass five flow patterns for the Petlyuk column derived from the Column Profile Map techniques.

In order to exhibit the value of the Column Profile Map techniques developed by Tapp et al. (2004) to higher order systems, the design methods are applied to the fully thermally coupled Kaibel column under sharp split conditions. From the results of the topological analysis, it is shown that, for set product specifications, when dealing with ideal systems (constant relative volatilities), there is only one set of feasible operating parameters. The line of solutions for feasible profile

intersection is then sectioned and the CPM-E technique is applied to the quaternary configuration that produces all feasible operating parameters.

The Column Profile Map technique has also been applied to the design of a variety of quaternary feeds for sets of columns consisting of a main column with various combinations of side rectifiers and strippers. The graphical nature of the technique allows one to easily assess feasible designs for systems with less than five components, but is shown to algebraically extend to higher order systems. The minimum vapour requirements of the various coupled side unit systems are compared using the Column Profile Map-Eigenvector technique.