

## ABSTRACT

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Low-cost and Energy-efficient Solutions for Multicomponent Distillation.  
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Distillation accounts for 90-95% of all the separations on a chemical plant, and for about 3% of the world energy consumption. Even modest improvements to the process of distillation can have tremendous impact on the chemical economy, world over. The goal of a major part of this thesis is to use process intensification methods to present, thoroughly investigate and systematically synthesize new processes for multicomponent separations which can serve as attractive candidates for distillation technology of tomorrow.

Industrial application of dividing wall columns (DWCs) for multicomponent separation has gained significance in recent years. We realize that only a small fraction of possible DWCs have been so far presented and considered for implementation to separate mixtures containing three and four components. In this work, we present a multitude of hitherto unknown DWCs for n-component distillation. A reason for this drastic expansion in available DWCs is the identification that a strategy called the 'conversion of a thermal coupling to a liquid-only transfer stream' could be applied to DWCs. For the example of four- and five-component FTC distillation alone, while only one DWC was known so far for over fifty years, we have now identified 35 and 575 new DWCs. Further, among the new DWCs, we have identified a subset of DWCs in which the vapor flow in every section of the DWC can be regulated during operation by means external to the column. This feature makes it possible to build and operate the DWCs

near optimality and ensure purity of product streams. Such an outcome could potentially lead to over 30% saving on operating and capital costs in comparison to processes currently in operation.

Further, we propose and study general methods to consolidate distillation columns of a distillation configuration using heat and mass integration with an additional section. The proposed method encompasses all heat and mass integrations known till date, and includes many more. Each heat and mass integration eliminates a distillation column, a condenser, a reboiler and the heat duty associated with a reboiler. Thus, heat and mass integration can potentially offer significant capital and operating cost benefits. Furthermore, we make a comprehensive comparison between the conventional column-consolidation and the proposed column-consolidation to understand when the conventional strategy is inefficient due to pronounced remixing losses. Finally, we present a preliminary formulation to synthesize thermodynamically equivalent versions of thermally coupled configurations.