

Abstract

Declining petroleum reserves, increasing fuel demands and environmental problems have attracted increasing research attention in improving the energetic potential of separation processes dominated by distillation. Thermal integration has emerged as an effective way of reducing the energy consumption through the improvement of thermodynamic efficiency. Among the various thermally integrated techniques developed so far, the internally heat integrated distillation column (HIDiC) and the direct vapor recompression column (VRC) have proved their energetic and economic potential. The present research work aims at developing the intensified thermal integration schemes by combining the HIDiC and the VRC, thereby acquiring the benefit of both of them.

At first, we develop an intensified heat integration scheme by integrating the classical VRC in HIDiC column for economic feasibility analysis. For a multicomponent hydrocarbon system, the intensified HIDiC-VRC system shows its superiority over the general HIDiC and the conventional standalone column in terms of energy savings and cost. Subsequently, this heat integration scheme is extended to apply on a reactive pressure-swing distillation (PSD) column.

To extend the applicability of VRC column to the wide-boiling mixture separations, a multi-stage VRC scheme coupled with single as well as double intermediate reboiler (IR) is proposed. This advanced form of VRC system is successfully applied on a sample ethyl *tert*-butyl ether (ETBE) column. By performing a detailed analysis, it is observed that this novel configuration provides a significant energy savings and better economic figures compared to the classical VRC and its conventional standalone column.

Finally, a novel configuration of a thermally integrated distillation column is proposed by introducing the multi-stage VRC with intermediate reboiler (VRCIR) in the HIDiC scheme. To illustrate a couple of variants of this advanced form of intensified configuration, we simulate a multicomponent distillation process that fractionates a hydrocarbon mixture having components with widely different boiling points.

Keywords: Internally heat integrated distillation column (HIDiC), vapor recompression column (VRC), intensified HIDiC-VRC, multi-stage VRC with intermediate reboiler (VRCIR), intensified HIDiC-VRCIR, simulation experiments