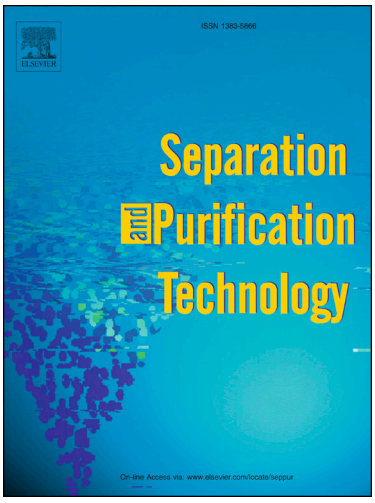

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Internally heat integrated batch distillation: vapor recompression and nonlinear control

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Abstract

This work proposes a vapor-recompressed heat integration scheme in batch distillation column and its nonlinear control. For this, first a thermal coupling is made to form a heat integrated batch distillation column (HIBDC). To further improve energetic and economic potential, a mechanical heat pump system is introduced in the HIBDC, which gives rise to the vapor-recompressed HIBDC (VRHIBDC). For a ternary hydrocarbon system, this VRHIBDC exhibits superiority in the aspects of energy savings and economic performance over the HIBDC with respect to the conventional batch distillation column (CBDC). Aiming to achieve a constant product composition and to collect higher amount of distillate from the VRHIBDC column, an extended generic model controller (EGMC) is formulated. To obtain the state information required for this model-based controller simulation, two nonlinear observers, namely high gain observer (HGO) and extended Kalman filter (EKF), are devised and then coupled with the EGMC, yielding the EGMC-HGO and EGMC-EKF, respectively. To avoid the design complexity and computational load, both the observers are designed based on only the component mole balance equation around the reflux drum. The open-loop performance of the EKF shows its superiority over the HGO for the same example system. Subsequently, the comparative closed-loop performance is evaluated between the EGMC-HGO and EGMC-EKF with respect to a traditional proportional-integral (PI) controller. It is investigated that the EGMC-EKF shows the best result followed by EGMC-HGO.

Keywords: Internal heat integration; vapor recompression; multicomponent batch distillation; energy savings; economics; nonlinear control

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