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Cyclic operation as optimal control reflux policy of binary mixture batch distillation

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1 Highlights

- We revisit the maximum distillate optimal control problem of binary batch distillation.
- The distillate flow rate is used as control variable instead of the reflux.
- We introduced a new state variable as the purity deviation.
- For the first time, the cyclic reflux policy is an optimal control solution.
- The cyclic policy achieves 13% more product recovery than the variable reflux policy.

Abstract

We revisit the maximum distillate optimal control problem of batch distillation of non-ideal binary zeotropic mixtures. The direct method with full discretization is used. The problem formulation is based on full column dynamics and the distillate flow rate is used as control variable instead of the reflux. The purity constraint is handled as a new state variable, the purity deviation. Literature simulations showed that the cyclic reflux policy (bang-bang type control) performs better than variable reflux (singular type control) or constant reflux policy for small amount of light product in the load. For the first time, a cyclic reflux policy is found as the optimal control solution. The results are confirmed by rigorous simulation of the batch distillation, as the cyclic policy improves by 13% the product recovery over the variable reflux policy. Influence of the relative volatility, vapour flow rate, plate hold-up and initial load is discussed.