Operating Strategy of Heteroazeotropic Batch Distillation Systems

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Mixtures containing azeotrope or close-boiling can be separated by adding an entrainer into the system to form an additional heterogeneous minimum-boiling azeotrope. This heterogenous azeotrope can be separated in a decanter at the top of the column into aqueous phase and organic phase. In this paper, the operating strategy of heteroazeotropic batch distillation for two mixture systems having different residue curve maps will be investigated. The purpose of the batch distillation operation is to recover near pure components in the mixture and also to recover near pure entrainer for further batch usage. The goal of the operating strategy is to minimize total batch time and also to obtain high recovery percentage of the three components in the system.

The first system is to separate acetic acid and water. This mixture does not form azeotrope, however because of tangent pinch on the pure water end it is customary in industry to add an entrainer into this mixture to aid the separation via heterogeneous azeotropic distillation. This investigation shows that although iso-butyl acetate is a good entrainer for acetic acid dehydration operating at continuous mode, it is not suitable for heteroazeotropic batch distillation. Instead, a much better entrainer was found to be vinyl acetate when acetic acid dehydration system is operated in batch mode. Extremely simple operating strategy of this system is developed to simultaneous accumulate aqueous and organic phase materials in the decanter and recover near pure acetic acid at the end of the batch. From dynamic simulation results, it is found that the proposed operating strategy is very robust in terms of the setting of the operating variables.

The second system is to separate Propylene glycol Monomethyl ether (PM) and water. There is an azeotrope for this mixture, thus using simple batch distillation will not obtain two pure components. However, by adding isopropyl acetate into this mixture, a heterogeneous minimum-boiling azeotrope of isopropyl acetate-water is formed. With the same simple operating strategy used in acetic acid dehydration system, near pure water product can be accumulated in the aqueous phase of the decanter and simultaneously organic product (mostly isopropyl acetate) can be accumulated in the organic phase of the decanter. The pure PM is collected at the end of the batch from bottom still. The organic product, although not in pure entrainer form, is demonstrated to be successfully used in the following batch run.

The key control loop in the proposed operating strategy is a middle tray temperature loop which can easily be implemented in industry. Rigorous dynamic modeling from the start-up of the batch run until the end of the batch can be simulated using Aspen Dynamics^{TM}.