Steady State Multiplicity of Novel Reactive Distillation Combined Distillation Column with Side Reactors for the Production of Cyclohexyl Acetate

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Abstract

Multiple steady states (MSS) are featured as several output results such as product compositions relied on a given set of input conditions including reflux ratio and boilup flow rates. MSS in processes like simple binary distillation, azeotropic distillation and reactive distillation have been reported in the last two decades. To design a process, it is important to discover if all MSS within the practical domain of operating variable are desirable and how the column responds to changes in operation variables.

In this work, MSS of reactive distillation that combines distillation column with side reactors for the production of cyclohexyl acetate were theoretically studied. A set of steady-state solution branches for product content at the bottom with the variation of reboiler heat duty were traced based on the “Sensitivity” and “Design Specs/Very” functions in Aspen Plus. For identical module and feed specifications, three distinctly different composition profiles corresponding to high/medium/low conversion of cyclohexene respectively were obtained. The main variables that affect the steady state behavior are the reboiler heat duty, the number of stripping stages and the catalyst loading amount.

To explore the specific cause of the MSS in the integrated process, residual curve analysis was presented in both the actual and ideal ternary systems for comparison. The bottom-product point is not singular and a distillation trajectory can pass through the material balance curve, which explains the existence of MSS. The different conversion steady-state composition profiles obtained in the process simulations correspond to residue curves with starting/ending points in different composition regions.

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