ABSTRACT

This work aims at synthesizing the extended generic model controller (EGMC) coupling with different state estimators for energy efficient cost effective distillation columns. The differential geometry based EGMC controller is quite flexible in that it can be used for processes having any number of relative orders. At first, we develop the high gain observer (HGO) and neuro-estimator (NE) to provide state information to the EGMC controller. Obtaining better performance from the HGO than NE for a reactive distillation column (ethylene glycol system) in both open-loop and closed-loop study, the hybrid EGMC-HGO scheme is forwarded for further advancement and use. In the subsequent study, attempt is made to enhance the energetic and economic potential of batch distillation, for which vapor recompression is introduced between the overhead vapor and reboiler content. Showing a substantial improvement in terms of utility consumption and total annual cost (TAC) with reference to a conventional batch reactive distillation column (butyl acetate system), it is subjected to control with the EGMC-HGO to maintain constant distillate composition. Compared to the traditional proportional integral (PI) controller, the model based EGMC provides a better product purity and larger amount of distillate collected. In the next study, a soft sensor is developed based on artificial neural network (ANN) to infer the distillate composition based on measured tray temperature and it is coupled with the HGO, yielding neuro HGO (NHGO). Additionally, we develop a neuro extended Kalman filter (NEKF) in the similar fashion to compare with NHGO for a reactive batch distillation (ethyl acetate system). Investigating the comparative performance between NHGO and NEKF with (closed-loop) and without EGMC (open-loop), attempt is made to further compare them in the next study. For this, heat integration is proposed in a ternary batch distillation (cyclohexane/*n*-heptane/toluene) by horizontally dividing the tray tower into two sections. The bottom section that includes the reboiler is operated at nominal pressure, whereas the top section that accompanies the condenser is operated at elevated pressure by installing an overhead compressor. These two diabatic sections are thermally coupled by a series of internal heat exchangers placed between them. Achieving energy savings and cost benefit by this heat integrated configuration over its conventional analogous, it is further used to illustrate the EGMC controller. It is confirmed that the EGMC-EKF shows a better performance than the EGMC-HGO. This nonlinear observer based EGMC controller is recommended for online use because of its simplicity, ease of tuning and high-quality control.

Keywords: Extended generic model control; state estimator; soft sensor; reactive distillation; batch processing; vapor recompression; heat integration