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Control of Laboratory Distillation Column with Methanol-Water Mixture

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Distillation process is a liquid-mixture separation method based on different volatility of individual components of a mixture. Distillation column consists typically of several trays that enhance vapor-liquid mass transfer. The reboiler, condenser, and trays must be properly controlled using a dedicated automation technology, appropriate control scheme, and well-designed controllers to achieve a desirable operation.

In this work, we perform the methanol-water separation in a laboratory distillation column UOP3CC manufactured by Armfield. The plant is further upgraded in house with feed preheating and pressure-based reboiler-level measurement. A PLC-based automation system is installed at the column. Among the possible control schemes, there are several pairings of input and output variables. Here, we use the LV control configuration and we achieve the product quality control by tracking the desired top and bottom temperatures. The control is realized via MATLAB/Simulink thanks to the connection to a web-server, which communicates with the automation system.

There are several controllers employed at the column. The feed temperature is controlled via proportional (P) controllers that adjusts the heat power of a feed preheater. Control of reboiler liquid level is achieved by P-controller regulated flowrate of the bottom pump. To regulate temperature in the reboiler, we employ a proportional-integral (PI) controller linked to the heat duty of the reboiler. The reflux ratio is adjusted to control the temperature at the top of the column. The temperature controllers were designed and simulated in MATLAB/Simulink and further verified in a high-fidelity simulation using AVEVA Process Simulation.

The implemented proportional-integral (PI) regulators exhibit solid performance in tracking the setpoints and effectively mitigating disturbances. During step changes in set points, the controllers demonstrate prompt response and maintain stable operation, ensuring that desired process conditions are achieved. The results are also validated against simulations in AVEVA Process Simulation. The comparison reveals close agreement between the actual system performance and the simulated behavior, confirming the effectiveness of our control strategy. The future work will involve design of advanced process controllers and a study of optimal start-up of the column.

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