Modeling and Control of A Multiple Effect Falling Film Evaporator Plant

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Abstract

The purpose of a falling film evaporator is to concentrate different fluids. These evaporators possess high heat transfer coefficients, can operate at small driving forces, and are less susceptible to scaling. In the pulp and paper industry, such evaporators are used to concentrate the black liquor that results from the pulp washing. It is very important that the black liquor that is the feed to the recovery boiler has consistent solids content that is within required specifications. The recovery boiler is a major power source and a critical equipment in the chemical regeneration cycle hence, its performance affects the overall mill performance.

The first part of this work develops a fundamental distributed parameter model of a falling film multiple effect evaporator system that consists of four evaporators and one superconcentrator (three evaporators in one unit). The model accounts for condensation, heating, and evaporation zones of the plate stack, the evaporator inventory, the recirculation loops, and the pressure dynamics among the evaporators. Key modeling and experimental features will be presented and the performance of the model to expected disturbances will be discussed. Additionally steady state results of the multiple effect evaporator plant are validated against real plant data.

The second part investigates centralized and decentralized control strategies to regulate the multiple effect falling film evaporator plant. The decentralized control strategy reflects the practice used in the pulp and paper industry. Since the integration of the distributed model is very computationally expensive, a lumped model (system of ordinary differential equations) is used instead to develop a model-based controller. The performance results of the decentralized and centralized control strategies on the multiple effect falling film evaporator plant are presented and compared.

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