

Developing a Simulator for Multiple Effects Falling Film Evaporator

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Abstract

Simulator of multiple effects falling film evaporator of milk and whey powder factories has been developed via Simulink in MatLab 6.1 environment. The simulator eases the study of the plant without loss of energy and material. In this regard, controller's parameters of the plant are optimized. Further, the plant performance is compared with the simulator results after applying new controller's parameters to them. A good agreement is observed between plant data and simulator results.

Plant model that is used in the simulator is developed in state-space and it is identified using a set of plant data and identification toolbox of MatLab 6.1. The model is capable in predicting the plant performance when its results are compared with another set of plant data.

Introduction

The Plant

The major equipment of the plant is three evaporators (E-1301 -03), three separators (S-1401-03), ejectors, barometric condenser and vacuum pumps, circulating pumps and condensate pumps.

Evaporators are vertical one pass shell and tube heat exchanger with saturated steam in the shell and concentrating liquid in the tubes. Milk or whey is distributed over the tubes so that they go down as a thin film in the interior wall of the tubes. As they fall, the evaporation of the water takes place and the liquid become more concentrated. The heat of evaporation comes from condensation of saturated steam in the shell.

Separators are used to separate entrained concentrated liquid from the vapor via the centrifugal force as they leave the tubes. They are installed next to the evaporators. Ejectors are used to increase the efficiency of the vapor usage, vacuum pumps are used to produce necessary suction of the air in the evaporators and condensate pumps are used to discharge the condensate of saturated steam produced in the shell. Finally, circulating pump is used to circulate the liquid before meeting the specified concentration. A multiple effects falling film evaporator is shown schematically in figure 1.

Milk or whey go through evaporators where they are concentrated to 48% total solid concentration. Vapor produced in upstream evaporators is used to supply heat to downstream evaporators.

Vapor from evaporator E-1303 that is separated in S-1403 is sucked by a barometric condenser where is condensed. Therefore, condenser in addition to the vacuum pump and ejector controls the vacuum through the plant. Hence, its operation has an important effect on the operation of the plant.

Live steam from boiler is used as the motive fluid in the ejector where it mixes with some vapor from E-1302 (separated in S-1402). The resultant vapor leaves the ejector and goes to the evaporator E-1301 as heat supplier.