EVAPORATING PROCESS SIMULATION OF BLACK LIQUOR IN FALLING FILM EVAPORATOR WITH AIR FLOW

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ABSTRACT

Evaporator is an equipment widely used in chemical industries for concentrating solutions. Falling film evaporator is one of the evaporators widely used in the pulp industries for concentrating black liquor. The advantages of it is the high rate of heat transfer and residence time is relatively short. So it can be used for concentrating fluids that are sensitive to heat. One of the method to increase the falling film evaporator’s performance is by blowing air which aims to reduce the partial pressure of water vapor, so that will decrease the boiling point of the solution.

This research aims to do theoretical analysis about the phenomenon of heat and mass transfer in falling film evaporator with black liquor-air system and to determine the mathematical model and numerical solution to predict the performance of falling film evaporator. Systems considered was laboratory scale Falling Film Evaporator with 2m column length and 2.54 cm column diameter. Temperature distribution and the concentration of products were obtained by performing the development of a mathematical model of mass and heat balance calculations generating system of differential equations solved numerically by Runge-Kutta order 4 method and finite difference using the MATLAB software. The model parameters were determined by fitting the model with experimental data (Irawan and Kurniawan,
2010) using Hookjeeve minimalization method. The variables studied in this research were liquid flow rate (100; 130; 150 l/h), air flow rate (4; 6 m³/hr) with initial black liquor concentration of 5.92%.

The research produced a computer program in MATLAB which can predict distribution of liquid temperature (LT), distribution of gas temperature (GT) and the distribution of concentration (%) for black liquor evaporation in a falling film evaporator. This program also predict the concentration of black liquor solution outflow evaporator for varying conditions. In this research, the highest concentration of outlet black liquor results come out, gained 15.69%, when the solution flow rate 100 l/h and gas flow rate of 6 m³/hr. This research also obtained heat and mass transfer coefficient correlation. The predicted outlet black liquor concentration using mass and heat transfer coefficient obtained from this study agrees very well with Irawan and Kurniawan (2010) experiment with average error 8.096%. When the prediction used mass and heat transfer coefficient correlation from literature (Geankoplis, 2003) the error is 12.993%.

Keywords: simulation, falling film, evaporator, black liquor