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Prediction of flooding and pressure drop in a spinning cone column using neural networks

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Abstract

Spinning cone column as a distillation tower has various applications in food industry. It has a complex geometric structure which makes the modeling of liquid and gas regimes in the column rather difficult.In the last decade, artificial neural networks havebeen used in various industries considerably. Unlike empirical correlation, neural network does not requirephysical mechanism which occurs in column. Therefore, in this research the effect of tray speed, pressure drop, cone spacing, and flooding for both small and large scales operation has been examined using artificial neural network. Furthermore, variation of gas and liquid flow rate in an industrial scale spinning cone column has also been evaluated. To obtain this objective, multilayer perceptron structure and Levenberg-Marquart training algorithm has been utilized. The findings of this study reveal that the predictions of this work are much accurate than those obtained from the existing empirical correlation. There also exists a good compatibility between the pressure drop values predicted from the present study and the experimental data in both dry and wet state (normalized bias = −0.00232, mean squared error = 0.0021, and root mean squared error = 0.0021). From the scheme adopted in this work, the spinning cone column capacity at different operating conditions could be estimated more accurately than the exiting correlations.

Keywords: Flooding, Neural networks, Multi layer perceptron, Spinning cone column

Background

Spinning cone column (SCC) as a distillation tower has various applications in the food industry. The spinning cone column is a gas-liquid contacting device consisting of a vertical countercurrent flow system, which contains a succession of alternate rotating and stationary metal cones, whose upper surfaces are wetted with a thin film of liquid. Liquid flows down the upper surfaces of the stationary cones under the influence of gravity and moves up the upper surfaces of the rotating cones in a thin film by the action of the applied centrifugal force. Vapor flows up the column and traverses the successive fixed and rotating cones [1]. Figure 1 shows the liquid and gas flow regimes in a SCC. Flooding limit is an important criterion in the distillation tower, since it is an index of tower's capacity. By knowing the geometric structure of the rotary conical tower, we could determine the effective parameters on the flooding such as gas flow rate, liquid flow rate, cone spacing, and rotation speed of the trays.

In the last decade, artificial neural networks have been used in various industries considerably [2]. Neural networks are nonlinear calculation algorithms for images, signals, and numerical data processing. Regarding some features of neural networks such as internal dynamic of neural networks in prediction, changing information error, unnecessary information in input data, employing neural networks in the engineering field as a tool to control and observe the process performance has been increased substantially. Multilayer perceptron is one of the most frequent structures which are utilized in neural networks [3].

Spinning cone column has a complex geometric structure which makes the modeling of liquid and gas regimes in the column rather difficult. Unlike empirical correlation, neural network does not require physical mechanism which occurs in column. Furthermore, multilayer perceptron structure could predict values outside the training limit. Therefore, in this research, the effect of tray speed, pressure drop, cone spacing, flooding for both small and large scales operation has been examined using artificial neural network. Furthermore, variation of gas and liquid flow rate in an industrial scale spinning cone column has also been evaluated.

Rotatory conical columns

The first research on SCC was carried out in 1937 by Pegram and co-workers which gave the details of the

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