Journal of Natural Gas Science and Engineering 3 (2011) 319–325

Contents lists available at ScienceDirect

Journal of Natural Gas Science and Engineering

journal homepage: www.elsevier.com/locate/jngse

Prediction of the overall sieve tray efficiency for a group of hydrocarbons, an artificial neural network approach

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ARTICLE INFO

Article history:
Received 19 December 2010
Received in revised form
8 January 2011
Accepted 24 January 2011
Available online

Keywords:
Overall tray efficiency
Murphree efficiency
Sieve tray
Multi-layer perceptron
Artificial neural networks
Hydrocarbons

ABSTRACT

Mass transfer efficiency is of great importance in the design and analysis of the sieve tray columns, as it relates theoretical to the actual number of stages. However, the empirical models that have so far been presented for the estimation of the tray efficiency are either confined to a particular system or not sufficiently accurate. On the other hand, neural networks are utilized in cases where either mathematical modeling could not be applied or the relationships between the parameters are complex. Therefore, it is the aim of this research to utilize neural network in predicting the overall sieve tray efficiency. To obtain this objective, the overall sieve tray efficiency for eight different compositions (i.e., ethanol/water, acetone/water, methanol/water, acetic-acid/water, toluene/water, methyl-isobutyl-ketone (i.e., MIBK)/water, aniline/nitrobenzene and cyclo-hexane/n-heptane) as a single hydrocarbon system has been computed, using artificial neural network. To assess the performance of the technique, the predicted values of the neural networks have been compared with the experimental data and the correlation proposed by the Garcia and Fair (Garcia and Fair, 2000). The findings of this research reveal that there exist a mean absolute error of 1.21 percent which is negligible compared to the correlation presented by Garcia and Fair with absolute error of 18.22 percent. Therefore, the results of this work demonstrate that multi-layer perceptron neural network could provide a good practice of predicting the overall sieve tray efficiency and with a good degree of accuracy.

1. Introduction

The cross-flow sieve tray is a popular phase-contacting device for the commercial distillation columns. Its nonproprietary nature, simplicity of design, and effectiveness of contacting are some of the attractive features of this device which have been used over the past 150 years (Garcia and Fair, 2000). Their usages have been reduced in the first half of the twentieth century. However, as the cost of its construction is low in contrast to other types of trays, therefore nowadays it has now been widely applied (Treybal, 1998). Basically, a sieve tray is composed of a perforated plate where the liquid moves over it and then flows to the lower plate. On the other hand, vapor flows vertically through the holes where a contact between the vapor and liquid phase occurs (Olivier and Eldridge, 2002). Mass transfer efficiency in the sieve tray is a crucial criterion in the analysis of the sieve tray columns, as it relates the theoretical to the actual number of stages. The first step in the design of such a column is the evaluation of the required theoretical stages which could provide the estimation of the necessary separation. This is usually achieved either through modeling or utilizing softwares. The next step is to calculate the theoretical from the actual stages which involve the computation of the point efficiency and consequently converting it to overall tray efficiency (i.e., Muphree efficiency). The number of the actual plates in the column could then be easily determined through the Murphree efficiency. In the recent years a lot of research has been conducted for the estimation of the number of theoretical stages; however, less attention have been made for converting it to the number of actual plates. This is due to complex nature of the transport mechanism between phases which has not yet fully been understood so far (Garcia and Fair, 2000).

Several empirical correlations have been proposed in the literature for the determination of the tray efficiency; however, they are only suitable for the initial guesses (Drickamer and Bradford, 1943; O'Connell, 1946). The first empirical model has been proposed by Geddes (Geddes, 1946). The flow regime in Geddes' model is assumed as a bubbly flow. These isolated bubbles are grown in the fluid; however, it is not what really occurs on the sieve plates in

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1875-5100/$ – see front matter © 2011 Published by Elsevier B.V.
doi:10.1016/j.jngse.2011.01.002