CHEMICAL ENGINEERING TRANSACTIONS
VOL. 45, 2015
A publication of AIDIC
The Italian Association of Chemical Engineering
www.aidic.it/cet
Guest Editors: Petar Sabev Varbanov, Jiří Jaromír Klemeš, Sharifah Rafidah Wan Alwi, Jun Yow Yong, Xia Liu

ISBN 978-88-95608-36-5; **ISSN** 2283-9216
DOI: 10.3303/CET1545155

Process Optimization of DWC for Fatty Acid Fractionation using Taguchi Methods of Experimental Design

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Experimental design (ED) is a powerful technique for optimizing the performance of a process. Compared to a model-based optimization technique, ED does not require the development of mathematical formulation but nevertheless needs a good model or experimental setup and statistical analysis. This paper presents an ED based optimization approach of a dividing wall column (DWC) model for industrial oleochemical fatty acid fractionation. Taguchi method of ED will be used for the optimization of the control variables for efficient fractionation of fatty acid cuts, namely light-cut (LC), middle-cut (MC) and heavy-cut (HC). The DWC model was developed in Aspen Plus software using a rigorous four-column configuration. It is used to identify sensitive parameters, simulate experimental layout trials and results validation. The process is designed to achieve product purity of >99 mol.% LC and MC, and >90 mol.% for HC. A step-by-step approach to process optimization using Taguchi method is presented along with the statistical analysis results and their interpretation. The ED output will help in understanding the interaction between variables and their effects. With its simple, fast and non-tedious approach, ED using Taguchi method could prove its significance in improving the performance of fatty acid fractionation using DWC for possible industrial application.

1. Introduction

Optimization has been employed in various chemical engineering problems to find the best solution to a process within given bounds and constraints. One approach of optimization is by formulating the problem using model equations. This task requires the elements such as predictive model, objective function, constraints and control variables. Such an approach, however, requires extensive mathematical model development thus prone to modelling error, ill-defined problem, convergence issues and computational complexity. Another approach with less mathematical effort is through the use of a modular based process simulator which helps especially in developing highly interactive and complex processes. However, it still demands robust computational algorithms and prone to convergence problems. ED is an interesting alternative to model or equation based optimization. ED does not require extensive mathematical development; nevertheless, it needs a good model or experimental setup and statistical analysis. It is useful to study and understand process parameters interaction and then optimise the process performance using limited budget and resources. Taguchi method is a powerful ED technique (Antony et al., 2001), and has been applied successfully in many applications that involve complex process interactions. This paper discusses the application of Taguchi method for optimising a rigorous four column DWC model developed in Aspen Plus. A four column DWC configuration is a non-standard model in Aspen Plus and not easily converged. Carrying such a simulation requires experience and is computationally demanding. To achieve optimal design a lot of tuning is needed especially on sensitive parameters; for this, ED comes in handy. By implementing ED based optimization it is expected to minimize the computational complexity compared to model or equation based optimization i.e. Aspen optimization tool. This way, the complex model development using process simulators could be utilised along with a simpler approach for optimization; hence, it provides a simpler and practical approach for optimizing the performance of the process. The general steps for optimization using Taguchi method is illustrated in Figure 1.

Please cite this article as: Othman M.R., Amran U.I., Rangaiah G.P., 2015, Process optimization of dwc for fatty acid fractionation using taguchi methods of experimental design, Chemical Engineering Transactions, 45, 925-930 DOI:10.3303/CET1545155