Environmental Engineering and Management Journal *March 2015, Vol.14, No. 3, 509-517*
http://omicron.ch.tuiasi.ro/EEMJ/

"Gheorghe Asachi" Technical University of Iasi, Romania

DESIGN AND PERFORMANCE EVALUATION OF A PLANT FOR GLYCEROL CONVERSION TO ACROLEIN

Ionut Banu*, Georgiana Guta, Costin Sorin Bildea, Grigore Bozga

University Politehnica of Bucharest, Department of Chemical and Biochemical Engineering, 313 Spl. Independentei, 060042 Bucharest, Romania

Abstract

The development of biodiesel industry in the recent past brought into discussion the valorization of glycerol as the byproduct of this technology. Dehydration of glycerol leads to acrolein, mainly used as a raw material in the production of acrylic acid and its esters. Several research efforts dealing with the synthesis of acrolein from glycerol are reported in the literature. However, they are limited to catalyst testing on laboratory scale, no attention being paid to the process feasibility at an industrial scale. The goal of this paper is to fill this gap by presenting an integrated design study of the glycerol dehydration process. A simplified kinetic model was developed based on published data, this one being able to predict with sufficient accuracy the rate of the main reaction and the formation of relevant by-products (carbonyl compounds, hydrocarbons, carbon monoxide and coke). A reaction system was designed, similar to the reactor-regenerator unit usually used in hydrocarbon catalytic cracking (FCC). Moreover, the operating conditions were determined in such a way to maximize the selectivity and ensure the autothermal operation. The reactor effluent is sent to a separation section consisting mainly in distillation units. Due to formation of a low-boiling azeotrope, extractive distillation is employed for separating the acrolein-water mixture, using a part of the fresh glycerol feed as solvent. For a set of typical operating conditions, the separation section was designed in Aspen Plus environment. An economic evaluation study was performed using Aspen Economic Evaluation module, following which an acrolein price of 1.13 EUR/kg was determined. By comparing this value with the market one of 3.3 EUR/kg, the feasibility of the proposed process from the economical point of view will be emphasized.

Key words: economic evaluation, glycerol valorization, kinetic model, plant design, reactor-regenerator system

Received: November, 2014; Revised final: March, 2015; Accepted: March, 2015

* Author to whom all correspondence should be addressed: e-mail: i_banu@chim.upb.ro; Phone: (+)4 021 402 3938