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MODELING OF MALEIC ANHYDRIDE PRODUCTION FROM A MIXTURE OF n-BUTANE AND BUTENES IN FLUIDIZED BED REACTOR

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***Abstract*—** The aim of this work was to model the catalytic oxidation of n-butane and butenes (Raffinate II) mixture to maleic anhydride (MAN) over a vanadium-phosphorus oxide (VPO) catalyst in a fluidized bed reactor (FBR). The three phase Kunni–Levenspiel hydrodynamic model (K-L) was used to describe the reactor. The obtained differential equations were solved by the fourth order Runge–Kutta numeric method. The K-L model was validated by a fitting comparison with reported experimental data for MAN production from n-butane. For the n-butane and Raffinate mixture, the maximum calculated MAN yield was about 52% over the FBR emulsion with a 49% of Raffinate conversion, and 51% of MAN selectivity. As a conclusion, the simulation program demonstrated a suitable performance to predict MAN selectivity, reactants conversion, and MAN and reactants concentration profiles.

***Keywords*—** Maleic Anhydride, Fluidized Bed Reactor, n-butane, Raffinate II.

I. INTRODUCTION

Maleic anhydride (MAN) is the cis-butenedioic acid (maleic acid) anhydride, and is one of the intermediate products with the highest expected demand for the next four years (Table 1), (Brandstädter and Kraushaar-Czarnetzki, 2005; Cortelli, 2006; Gascón *et al.*, 2005). MAN world demand primarily depends on unsaturated polyester resins (UPR) production, lube oil adhesives synthesis and maleic and fumaric acids formation (Nexant ChemSystems Reports, 2005).

In 1930, National Aniline and Chemical first produced MAN industrially by Benzene catalytic oxidation in a fixed bed reactor (McKetta, 1983). Subsequently, production of MAN has been experimentally investigated by using different reactor types, such as fixed bed reactor (PBR), fluidized bed reactor (FBR), circulating fluidized bed reactor (CFB), two – zone fluidized bed reactor (TZFBR) and membrane reactor. These reactors were developed to improve reaction performance, increase heat and mass transfer rates and adjust reaction features. (Cortelli, 2006; Gascón *et al.*, 2005; Cruz *et al.*, 2005).

Fluidized bed reactors (Fig. 1) have been used in MAN production because of several advantages presented in transport phenomena when catalytic solid particles are suspended and transformed into a fluid-like state (Pugsley *et al.*, 1992).

Table 1. World MAN production capacity (Cortelli, 2006)

Year	**Capacity Kton**	**Production Kton**
1999	1213	949
2000	1213	949
2002	1207	985
2004	1267	1063
2007	1428	1182
2010	1511	1326

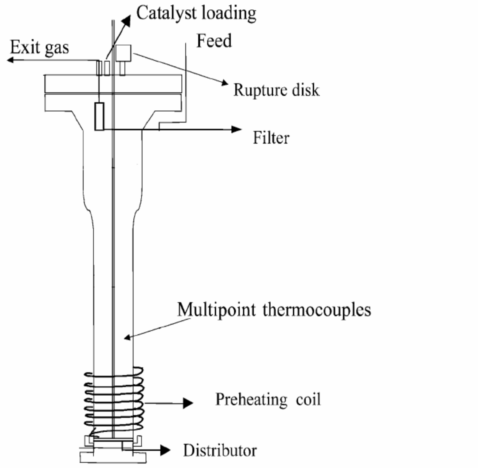

Figure 1. Fluidized Bed Reactor – Pilot Scale (Lorences *et al.*, 2003).

MAN production in a FBR presents desirable features as follows: (a) prevention of localized hot spot formation via rapid mixing of the catalyst particles, since a constant temperature is maintained throughout the bed by using a simple heat exchanger, even though the reactant and air are fed separately; (b) use of fine particles that allow an increment in the particle contact surface and reduction in the concentration and temperature gradients; (c) catalyst life is increased when hot spots are avoided; (d) feed composition can be 4% butane in air compare to 1.8% in a PBR; (e) the reactor diameter and the compressor investment and cost utilities could be reduced since the air rate decreases; (f) easier loading and unloading of the catalyst particles in a FBR than in a PBR; and (g) FBRs need a lower investment than PBRs, since FBRs can have double capacity of a PBR for a large scale plant (Contractor and Sleight, 1987).

Although FBRs have allowed to overcome some maleic anhydride production problems, they still have some drawbacks, such as (a) higher catalyst volume demanded compare to PBR; (b) tendency to lower MAN