Development of a User Interface for Design of SO2 Oxidation Fixed-Bed Reactors

A. Nagaraj[1], P. L. Mills[1]

[1]Texas A&M University - Kingsville, Kingsville, TX, USA

Abstract

H2SO4 is a very important chemical commodity, and indeed, a nation's H2SO4 production has been a reasonably good indicator of its industrial strength for the last century or so1,2. Nearly 350 MM tons of H2SO4 was produced in 20143.The demand for H2SO4 in United States exceeds the supply and hence to increase production, recycling and innovative clean technologies must be explored. From environmental perspective, SO2 is identified as one of the "criteria air pollutants" (ozone, particulate matter, carbon monoxide (CO), sulfur dioxide (SO2), nitrogen oxides (NOx) and lead) by US Environmental Protection Agency (US EPA). These pollutants can cause harm to human health, the environment and also cause property damage. Therefore EPA regulates these pollutants by development of human-based and/or environmentally-based criteria to set permissible levels. The catalytic oxidation of SO2 to SO3 which is heart of the H2SO4 production process is always incomplete due to equilibrium limitation. Hence unconverted SO2 emissions have to be controlled to meet environmental regulations before released into the atmosphere.

Currently the contact process is the only industrial method used for H2SO4 production due to favorable process economics4. Contact processes can be operated in either the presence or absence of water vapor. This leads to two different types of contact processes, namely, the dry-gas process and wet acid process. The schematic of a typical SO2 converter used in dry-gas contact process is shown in the Figure 1.

Typical adiabatic 4-pass converter profiles for the SO2 converter illustrated in Figure 1 are shown in Figure 2. These are based upon COMSOL Reaction Engineering Lab to describe adiabatic reactor performance with ideal plug flow of the gas. These results provide the incentive for developing new catalyst technology because the maximum SO2 conversion possible is 99.7%, which is adequate to meet current EPA regulations for SO2 emissions. However, it does not meet the anticipated future need to design H2SO4 plants with SO2 emissions < 100 ppm, or even < 10 ppm.

The primary objective of this study is to develop an application for the ideal plug flow reactor model using the Application Builder in the COMSOL Multiphysics® software to evaluate reactor parameters.

Reference

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3. HIS. Sulfuric Acid. Chemical Economics Handbook, (2014).

4. Friedman, L. J. and S. J. Friedman. The History of the Contact Sulfuric Acid Process. AIChE Clearwater Convention. Boca Raton, Florida, (2008).

Figures used in the abstract

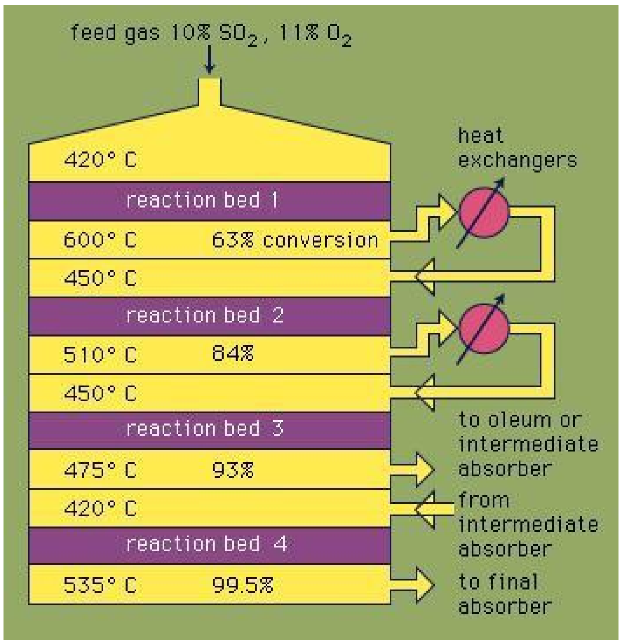

Figure 1: Schematic for a 4 pass catalytic converter for SO2 oxidation to SO3 (Image courtesy: http://www.britannica.com/technology/contact-process)

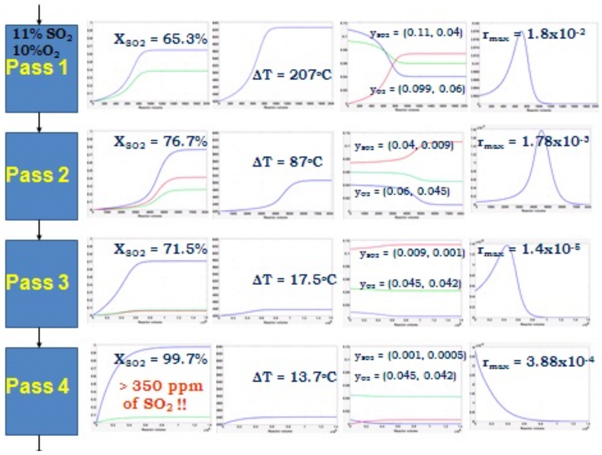

Figure 2: Adiabatic 4-pass converter profiles