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Modeling of three-phase radial flow reactor for diesel hydrotreating

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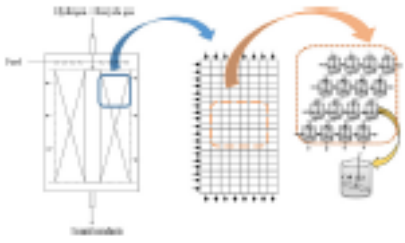
HIGHLIGHTS

- Mixing cell network model presented for industrial-scale three-phase Radial Flow Reactor for diesel hydrodesulfurization.
- 2D MCN model was developed for Radial flow Reactor (RFR) with one and five distributors to predict the product quality and bed temperature profiles.
- Reactions like hydrodesulphurization (HDS), Hydrodearomatization (HDA), and olefins saturation are taken into consideration.

GRAPHICAL ABSTRACT



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ABSTRACT

A mathematical model for a novel industrial-scale three-phase catalytic Radial Flow Reactor (RFR) has been developed using a two-dimensional mixing cell network (MCN) model. RFR is predominantly used for gaseous phase reactions in the petroleum refining industry. This work discusses the capabilities of three-phase RFR for diesel hydrodesulfurization. The reactions considered for the model development of diesel hydrodesulfurization are hydrodesulfurization, hydrodearomatization, and olefins saturation. Apart from the well-known advantage of RFR, such as pressure drop, the analysis revealed other benefits such as better product quality, reduced H_2S inhibition, no requirement of quench, high WABT. Simulations for RFR were performed for different gas distributors and results show that distributor design impacts the performance of reactor.

1. Introduction

Hydroprocessing is a key petroleum refinery operation to meet the ever-increasing demand for fuel (Ancheyta, 2011; Furimsky, 1998). Predominantly, Trickle Bed Reactors (TBR) are used for the majority of the hydroprocessing processes such as hydrotreating and hydrocracking (Rodríguez and Ancheyta, 2004; Sánchez et al., 2005; Sánchez and Ancheyta, 2007; Yadav and Roy, 2021). Typically three-phase catalytic TBR has a catalytic bed (fixed) with liquid and gas flowing either co-currently downwards or co-currently upwards. Although widely employed for hydroprocessing, TBR possesses shortcomings such as high bed pressure drop, feed vaporization, increased hydrogen sulphide inhibition, and reduced hydrogen concentration (Alvarez et al., 2011; Kam et al., 2005; Nekhamkina and Sheintuch, 2019; Ovalles et al., 2017). Radial Flow Reactor (RFR) is a novel reactor technology that addresses these shortcomings of conventional three-phase catalytic TBRs (Kareeri et al., 2006; Korsten, 2016; Leite et al., 2021; Parihar et al., 2018; Savoretti et al., 1999). RFR has been predominantly used for gaseous phase reactions such as reforming in petroleum refineries (Korsten, 2016; Nekhamkina and Sheintuch, 2019; Parihar et al., 2018). In RFR, liquid feed flows downward

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