A new generic reaction for modeling fluid catalytic cracking risers

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Abstract: A new generic reaction in the form of $PC_i \rightarrow PC_m + [i,m] \rightarrow PC_m + \lambda_{i,m}$ coke + surplusage has been proposed for describing the catalytic cracking behavior of petroleum narrow cuts or pseudo-components (PCs), where the rate constant formula is derived from the transition state theory and the coking amount is correlated to the properties of the intermediate substance [*i*,*m*]. In composing the cracking reaction network for feedstock and product oils, only product PC_m of the proposed generic reaction is used, which together with a criterion for excluding exothermic reactions, distinctly reduces the number of reactions in the network. With the proposed cracking reaction scheme coupled with special pseudo-components, a predictive one-dimensional steady state model for fluid catalytic cracking risers is formulated in the sense that for a given riser and given catalyst, the model parameters are independent of stock oils, product schemes and other operational conditions. The great correlating and predicting capability of the resulted model is tested with production data in different scenarios of four commercial risers.

Keywords: fluid catalytic cracking riser; kinetic modeling; pseudo-component; petroleum; steady state model; parameter estimation.

1. Introduction

Fluid catalytic cracking (FCC) is a critical process of petroleum refineries where heavy distillates such as vacuum gas oils or even residues are cracked to produce liquefied petroleum gas, gasoline, diesel and propylene. Design and operation optimizations of industrial FCC units are of great significance because the throughputs of such units are huge. Therefore, modeling and simulation of FCC processes have been an important topic of research ever since about 1940's. Notable early pioneers on this topic include [1,2], and more recent contributors include [3-11]. Pinheiro et al. [12] presented a comprehensive review on the subject of fluid catalytic cracking process modeling, simulation and control.

In modeling a fluid catalytic cracking unit, one challenging problem is to describe the chemical reactions of the feed and product oils which are complicated mixtures of numerous hydrocarbons and non-hydrocarbons. The kinetic models proposed in the past can be primarily classified by the entities used to express the oils. In the kinetic model of Weekman and Nace [13], the entities are three lumps, stock oil, gasoline (C5-410 ºF), and C3 + C4 + dry gas + coke. Jacob et al. [14] presented a kinetic of 10 lumps which are the gasoline (C_5-430 ºF), coke, and other eight light and

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