The fifteen lumped kinetics model for Fluid Catalytic Cracking of MIP process

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Abstract

Highlights

- The fifteen lumped kinetics model of MIP process
- Step measuring method is used to increase the reliability.
- The differential evolution algorithm is used to improve the parameters.

Introduction

Catalytic cracking process is to crack the heavy distillate into lighter and more valuable hydrocarbon products, with the condition of high temperature, low reaction pressure and existent catalyst. Its main industrial value is producing gasoline, diesel oil, liquefied petroleum gas and other important oil products. In MIP (Maximizing Iso-Paraffins) technology, the riser reactor is divided into two parts to provide different conditions for hydrocarbon cracking and olefin conversion. Specifically, the first part is similar to the previous FCC riser, which effect is cracking generation olefin hydrocarbon mixture quickly and thoroughly (high temperature, short contact time and high catalyst-to-oil ratio). However, in the second part, the products of olefins reaction are more beneficial to propylene, heterogeneous alkanes and aromatic hydrocarbons, so as to reduce the olefins content in the final product (low reaction temperature and long reaction time). In this paper, the kinetic lumped model is based on the heavy oil catalytic cracking of Jiujiang refinery. The whole lumps including material (saturate, aromatics, resins + asphaltene), diesel (paraffin, naphthenic hydrocarbon, olefin and aromatics), gasoline (paraffin, naphthenic hydrocarbon, olefin and aromatics), LPG (paraffin and olefin), dry gas and coke are divided to see their relationship. In the model, there are so many parameters need to solve, that the step measuring method is used to increase the reliability.
Methodology

1. All the parameters are calculated from different models step by step. The first model has seven lumps including saturate, aromatics, resins + asphaltene, diesel, gasoline, LPG, dry gas + coke. The second model just splits diesel of the first model. Then, in the following three models, gasoline, LPG and dry gas + coke are divided respectively. Finally, the last model contains the whole fifteen lumps. Throughout the process, the parameters that are solved from the previous model always sever as known condition for the later model.

2. In order to estimate the kinetic parameters of the model, the relative value of the parameters of the FCC lumping kinetic model was imitated firstly. According to the chemical properties of activation energy of each reaction, the activation energy was selected randomly and used to calculate the distribution of the raw oil in the MIP reaction system by four-order Runge-Kutta method. Then, the choice of high quality parameter set is based on the deviation of calculated value and actual value. Next, the differential evolution algorithm is used to improve the parameters. Finally, according to the Arrhenius equation, the activation energy data at different reaction temperatures were used to calculate the pre-exponential factors.

Results and Discussion

First of all, via the data comparison, the fitting effect of the model meets the requirements, and the prediction accuracy achieves the expected result. The feasibility of using the data to directly establish the dynamic model is demonstrated. Compared with the previous method, the required data volume is reduced, which reduces the workload. Secondly, the FCC model in HYSYS cannot reflect the MIP process, but the model is able to achieve. Thirdly, the model can be directly nested with optimization algorithm, which is aim to optimize and analyze the key operating variables.