Experimental Study & Modeling of Coke Formation in Pyrolysis of Naphtha

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Abstract. The aim of this study is to develop a coking model for the pyrolysis of naphtha that can be used to predict the coking rate from a given naphtha sample with commercial indices. For this purpose, a computer control pilot plant system designed and assembled, for studying the pyrolysis reaction kinetics, coke formation and different advance control algorithms. Experiments on the thermal cracking of naphtha were carried out in a tubular reactor under conditions as close as possible to those in the industrial operations. Developing a coking model requires a suitable model of thermal cracking reactor based on a reliable kinetic model. To obtain reliable results these models shall be solved simultaneously. Therefore, a complete reaction network was used. Then it was verified and tuned by pilot plant data. In the second series of experiments, coke formation during pyrolysis of naphtha in pilot plant system was studied. For better estimation of coking parameters, the experiments were carried out at different operating conditions.

1 Introduction

Thermal cracking of hydrocarbons is one of the main processes for the production of olefins. The feed, ranging from light gaseous hydrocarbons to gas oil, is cracked in 4-8 tubular coils suspended in a fired rectangular furnace. Mathematical models describing the simulation of the pyrolysis reactors need to be combined with complex kinetic models with important features such as coking, heat and mass transfer, firebox profiles and fluid dynamic characteristics. The present paper describes the development of a coking model for the pyrolysis of naphtha that can be used to predict the coking rate from a given naphtha sample with commercial indices. For this purpose, a computer control pilot plant system designed and assembled by ORG, for studying the pyrolysis reaction kinetics, coke formation and different advance control algorithms. Developing a coking model requires a suitable model of thermal cracking reactor based on a reliable kinetic model. To obtain reliable results these models shall be solved simultaneously. Therefore, the ORG complete reaction network was used. Then it was verified and tuned by pilot plant data. For better estimation of coking parameters, the experiments were carried out at different operating conditions.

2. Experimental Setup and Procedure

The setup, used for the experiments of the naphtha thermal cracking is a computer controlled pilot plant unit, shown schematically in Figure 1. The furnace is consisted of two electrical preheaters for the water and hydrocarbon feeds. An additional electrical heater is used for the reactor section. The preheaters are single zones and the reaction section heater is divided into eight zones, which can be heated independently to set any type of temperature profile. Each zone power can be controlled manually or by a control algorithm implemented on the process computer. The reactor is a 1 m long, 10 mm internal diameter tube, made of Inconel 600. There are eighteen thermocouples along the reactor, 8 inside