Refinery Scheduling Optimization Model and Scheduling Optimization Method based on Optimal Process Control

Dexian Huang, Xiaoyong Gao, Yongheng Jiang, Chao Shang
Department of Automation, Tsinghua University

Due to the more and more fierce market competition, the tighter and tighter supply of the crude oil, and the development of information technology in refineries, the refinery scheduling optimization has attracted increasing attentions in both academic and industrial communities. Because that the product yields of refinery process works vary obviously with the changes of operation conditions and crude, it is very challenging to formulate accurately the schedule model and obtain an operable schedule. As existing methods either adopted mean process models, or involve unrealizable operation modes, either the schedules can not be implemented or there will be wide difference between the realized schedule and computation one. Therefore, we propose an model formulation methods and integrated scheme of the plant-wide scheduling optimization based on optimal process control. Under the unit-wide model predictive control (MPC) and real time optimization, the primary and secondary processing units can work in finite number of optimal modes, and the hydro-upgrading processing unit can be controlled to a special accuracy, we propose the multi-mode scheduling model for primary and secondary processing units, and continuous scheduling model for hydro-upgrading units. A bi-level description method is proposed to minimize the process dynamics and improve the computational efficiency. The upper level of decision-making decides the units set to be adjusted step by step from the downstream units to upstream ones and its optimal modes of units adjusted which will appoint deterministic models for scheduling optimization. The lower level solves a particular sub-scheduling problem from the upper layer. The integrated strategy is validated on a simulation platform based on UniSim Operations. Furthermore, a piecewise linear based model method is proposed to deal with strong nonlinearity of the hydro-upgrading processing units (HUPUs). To handle the so-called "curse of partitions" of the compact representations of piecewise linear model, a simplicial partition strategy with alterable intervals together with its model construction method is proposed. By the proposed piecewise linear model, the original MINLP problem involving HUPUs schedule is converted into a MILP one, which can be solved by many mature solvers. A crude oil classification based multi-model method is proposed to handle model difficulty of the secondary processing units (SPUs) caused by variable charged crudes. A classification method based on the deep belief network is presented with blending retios of different feeding crudes as inputs and the blended crude type as the output, based on the analysis of both SPUsmechanism and the current refinery operations.

Keywords: Scheduling optimization model, Piecewise linear model, Deep learning, Scheduling optimization , Optimal process control.