Scheduling of upstream and downstream operations in crude oil refinery

Abstract

Global consumption of crude oil has been growing on average by 1.2 % annually for the last 10 years and has reached around 95 million barrels per day in the year 2018. The viability of refinery and the impact of the refinery to the environment mainly depend on the choice of crude oil, the refinery configuration, the desired product quality and types, and the environmental regulations. The lighter and sweeter the crude oil is, the more expensive the cost will be, but it requires less refinery upgrading and minimal disposal of wastes to the environment. However, the supply of such crude oil is decreasing, and the refinery process is becoming more complex to handle the heavy and poor-quality crude oils.

Desalting is one of the operations that become an integral part of the refinery in the last few decades. Moreover, targeting and maximizing economically more relevant product such as gasoline has become the strategy of refinery operations. Scheduling of crude refinery is crucial to maximizing the profitability of refinery without compromising the environmental regulations, the product quality and customers' demand. However, the difficulty to handle the nonlinearities and multiple criteria naturally existing in the scheduling of refinery operations, particularly in the scheduling of gasoline blending and distribution (SGBD) has remained unresolved. Besides, gasoline blending is a dynamic process due to its susceptibility to seasonal, geopolitical and socioeconomic conditions. Nowadays, to increase the use of renewable energy sources in gasoline, several nations are targeting ethanol as a blendstock in gasoline blending. However, few studies are reported on scheduling the blending of ethanol in gasoline.

In the present study, a mathematical model that incorporates desalting as a separates task and that allows a desalting tank to feed multiple distillation units is formulated to schedule the crude oil operation. The model is based on state task network (STN) formulation using a unit-specific event-based time representation.

Subsequently, a graphical genetic algorithm (GGA) based model involving a discrete-time representation is developed for both single- and multi-objective SGBD. In the single-objective formulation, the production cost is minimized, whereas, in the multi-objective formulation, the sum of the square of fluctuation in inter-period blending rate is additionally minimized. Further, the study is extended to formulate continuous time based graphical genetic algorithm model for both single and multi-objective in SGBD. The model uses the global event-based continuous-time representation. The proposed model is used to solve three industrial problems. Lastly, the continuous-time GGA model is used to handle demand uncertainty for bio-fuel surrogated gasoline. Minimizing the total production cost is the first objective in the single-objective optimization while minimizing the Reid vapour pressure inter-event fluctuation of the biofuel-gasoline blend is the additional objective in the multi-objective optimization. Four industrial problems involving biofuels (ethanol/ethanol-butanol blend) are solved to check the efficacy of the model.