Refinery Scheduling with Varying Crude: A Deep Belief Network Classification and Multimodel Approach

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In model-based refinery scheduling, the varying composition of the crude being refined is a major challenge, especially for those reaction processes. A classification based, multimodel approach is proposed to handle the frequently varying crude. The idea is to build a scheduling model for each type of feed crude, and the type can be determined using an online classifier. The recently emerged deep belief network is introduced to develop the classifier, which provides more accurate classification than the traditional neural network. The proposed method is demonstrated through modeling a fluidized catalytic cracking unit (the mostly affected by varying crude), and then the scheduling of a refinery that was carefully simulated to mimic the actual operation of a refinery in northern China. The results reveal that the multimodel approach is effective in handling varying crude. © 2014 American Institute of Chemical Engineers *AIChE J*, 00: 000–000, 2014

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Introduction

Refinery scheduling optimization has attracted increasing interests in both academic and industrial communities. One of the challenges faced by refineries is the varying composition of the crude oil being refined. This can happen because, first the crude can come from different sources (oil fields), and second the crude from the same source may also undergo slow change over time. The first situation is the primary cause of variability particularly in the context of short-term scheduling (time horizon of several days), during which the gradual change of the same crude is insignificant. From the practical perspective, it is not always possible to have a constant supply of crude from a single source; this is especially the case in a number of large scale refineries in northern China, where crude oil from up to 20 sources is routinely blended and processed. Therefore, in this study, we aim to address the impact of blended crude oil from different sources on refinery scheduling.

To further precisely represent the problem, variability in crude has different impact on different processing units in refinery. For distillation units involving no chemical reaction, the boiling point-based swing cut model[1,2] can adequately handle the variability. However, the secondary processing units (SPUs), which convert heavy fractions into lighter ones through various cracking reactions, are largely influenced by the chemical composition of the crude oil. For example, two feeds with similar boiling points may exhibit dramatic differences in the cracking performance and product yields.[3] One useful approach is to adjust the blending ratio of different crudes so as to minimize the variability in both supply and composition.[4–7] However, these optimization-based methods do not always reduce the variability to a level, at which the influence on processing units is sufficiently reduced. For the purpose of scheduling, accurate modeling of the impact of crude variability on SPUs is an open problem.

In the literature of scheduling and planning, a variety of studies have been reported to handle the model formulation problem. Pinto et al. stressed the need to address the influence of feed properties and operation conditions on the outlet properties, yield, and operation cost of processing units[8]; however, how to model such influence is still underexplored. Li et al. proposed a fractions transfer ratios model for planning,[1] but the model only considers the influence of operation conditions and cannot reflect the changeover of feed. Göthe-Lundgren et al. took a multimodel approach to handling the presence of multiple operating modes, one model representing the yield and product quality under each mode.[9] Similar method has been adopted in other studies[10,11]; but none of these considered the impact of varying crude. Shah

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