Journal of Process Control 22 (2012) 1122–1126

Contents lists available at SciVerse ScienceDirect

Journal of Process Control

journal homepage: www.elsevier.com/locate/jprocont

Inferential estimation of kerosene dry point in refineries with varying crudes

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ARTICLE INFO

Article history:
Received 26 October 2010
Received in revised form 10 February 2012
Accepted 31 March 2012
Available online 23 April 2012

Keywords:
Bootstrap aggregated model
Classifier
Data-driven models
Inferential estimation
Crude distillation

ABSTRACT

A bootstrap aggregated model approach to the estimation of product quality in refineries with varying crudes is proposed in this paper. The varying crudes cause the relationship between process variables and product quality variables to change, which makes product quality estimation by soft-sensors a difficult problem. The essential idea in this paper is to build an inferential estimation model for each type of feed oil and use an on-line feed oil classifier to determine the feed oil type. Bootstrap aggregated neural networks are used in developing the on-line feed oil classifier and a bootstrap aggregated partial least square regression model is developed for each data group corresponding to each type of feed crude oil. The amount of training data in crude oil distillation is usually small and this brings difficulties for classification and estimation modelling. In order to enhance model reliability and robustness, bootstrap aggregated models are developed. The inferential estimation results of kerosene dry point on both simulated data and industrial data show that the proposed method can significantly improve the overall inferential estimation performance.

1. Introduction

Crude oil distillation is a primary process in petro-chemical industry and its operation determines the resource usage efficiency and economic benefits of refineries. In order to properly control refinery operations, it is essential that product quality measurements are available. Since most of the quality indexes can hardly be measured in real-time, various soft-sensor methods have been proposed to estimate these indexes using measurable process variables and have been successfully applied in practice [1–4]. As the mechanism of the relationship between the quality variables and the process variables is too complicated and not possible to know comprehensively, empirical models are often used in soft-sensor methods and have good performance in many applications [5–7].

However, soft-sensing in crude oil distillation with varying feedstock remains a difficult problem because the relationship between the easy measured process variables and the difficultly measured quality variables varies with the types of crude oil processed. The types of crude oil change with suppliers. Even the crude oil from the same supplier may also vary in the hydrocarbon content. Furthermore, many refineries operate with mixed sources of crude oil with varying blending ratios. For different crude oil, the relationship between process variables and quality variables is generally different.

One natural idea is to develop an inferential estimation model for each type of crude oil (each supplier or oil filed). But this is unpractical as crude oil from the same supplier or oil field may vary in the hydrocarbon content. A more practical solution is to build models, respectively, according to the type of refinery feed oil (not the crude oil that composes the feed oil). The blending ratio and the type of crude oil are often known and furthermore lab analysis of feed oil composition can be occasionally carried out, so it is possible to obtain data for different types of refinery feed oil.

This paper proposes a multiple model based inferential estimation system integrated with on-line refinery feed oil classification. An inferential estimation model is developed for each type of refinery feed oil. A classifier is used to classify on-line data and determine the type of feed oil currently used and then the corresponding model is chosen to estimate the quality variables. Using on-line measurements of process variables, the feed crude oil is classified into different types, and historical process operation data are also classified into these groups. A bootstrap aggregated partial least square (PLS) regression model is developed for each data group corresponding to each type of feed crude oil. Each model has a favourable predictive capability upon the same type of oil but low predictive accuracy upon other types. During on-line operation, the feed crude oil type is first estimated from the classifier using on-line process measurements and then the corresponding PLS model is invoked.

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http://dx.doi.org/10.1016/j.jprocont.2012.03.011