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Data-Driven Soft Sensor Modeling Based on Twin Support Vector Regression for Cane Sugar Crystallization

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ABSTRACT

Cane sugar crystallization is a complex physical and chemical process and is related with many parameters. Due to the restriction of technical condition, some key parameters such as mother liquor purity and supersaturation, cannot be measured directly by existing sensors. This hinders the implementation of automatic control in cane sugar crystallization seriously. To handle this problem, a data-driven soft sensor modeling based on twin support vector regression is proposed to estimate the mother liquor purity and supersaturation. Seven easy-to-measure variables are chosen as input, including vacuum degree, temperature, massecuite level, steam pressure, steam temperature, feeding rate and massecuite brix. Two difficult-to-measure variables are chosen as output, including mother liquor supersaturation and mother liquor purity. The model parameters are optimized by combining the particle swarm optimization and the ten-fold cross-validation method. Experimental result indicates that this method performs well in aspects of prediction, approximation, learning speed, and generalization ability compared with BP, RBF and ELM, and is proved to have great effectiveness and reliability in cane sugar crystallization control.

Keywords: data-driven; twin support vector regression; soft sensor; particle swam optimization; model parameters optimization; crystallization.

1. Introduction

Cane sugar crystallization is a complex chemical and physical process involving both heat and mass transfer, and it is determined by many parameters such as the mother liquor supersaturation, purity, temperature, pressure, purity, liquor level and vacuum degree. However, the supersaturation and purity is unable to be measured by traditional physical sensors. This seriously hinders the growth of automatic control in cane sugar crystallization. In order to take correct operation actions so that the ideal product quality be achieved, it is desirable to estimate these immeasurable key parameters. Soft sensors have been widely considered due to its ability to estimate immeasurable parameters based on historical data and predictive model (Yu et al., 2012). Taking measurable parameters as