CONTROL OF A BATCH POLYMERIZATION SYSTEM USING HYBRID NEURAL NETWORK - FIRST PRINCIPLE MODEL

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In this work, the utilization of neural network in hybrid with first principle models for modelling and control of a batch polymerization process was investigated. Following the steps of the methodology, hybrid neural network (HNN) forward models and HNN inverse model of the process were first developed and then the performance of the model in direct inverse control strategy and internal model control (IMC) strategy was investigated. For comparison purposes, the performance of conventional neural network and PID controller in control was compared with the proposed HNN. The results show that HNN is able to control perfectly for both set points tracking and disturbance rejection studies.

On a étudié dans ce travail l'utilisation d'un réseau neuronal hybride avec des modèles basés sur les premiers principes dans le but de modéliser et contrôler un procédé de polymérisation discontinu. Au niveau méthodologique, on a d'abord mis au point des modèles anticipatifs à réseau neuronal hybride (HNN) et des modèles inverses à HNN pour le procédé, puis on a étudié la performance du modèle en stratégie de contrôle inverse directe et en stratégie de contrôle de modèle interne (IMC). À des fins de comparaison, la performance du contrôleur de réseau neuronal et de PID a été comparée au HNN proposé. Les résultats montrent que le HNN est capable de contrôler parfaitement en ce qui a trait aussi bien au suivi des points de consigne que du rejet des perturbations.

Keywords: hybrid neural networks, first principle model, batch polymerization, modelling, model-based control

INTRODUCTION

Commercially, in a polymerization process, the purpose of control is to ensure the end-use polymer meets the required properties such as molecular weight distribution, monomer conversion, copolymer composite distribution and degree of branching. Due to this reason, it is important to have a valid mechanistic model that is capable of predicting these process variables.

Nevertheless, models for polymerization reactors vary greatly in their complexity. Since there are no generalized models, which can be applied to all polymerization systems, careful experimental investigations are required for successful process designs. A survey of published works on the dynamic and steady-state modelling of polymerization reactors in the 1980’s can be found in the published paper of Penlidis et al. (1985). Nowadays, a lot of the polymerization process modelling is still carried out by using mathematical models (Lewin, 1996; Vega et al., 1997; Yao et al., 2001; Soares, 2001). This type of mathematical approach encompasses many difficulties and much time is spent to get the best model due to the complexity of a highly non-linear polymerization process (Latado et al., 2001).

Furthermore, to produce polymer with desired properties, the process variables such as temperature, molecular weight, molecular weight distribution (MWD), and viscosity must be tightly controlled. Researchers have been trying hard to look for a better controller or control algorithm for polymerization process control. For example, Karagöz et al. (2000), Rho et al. (1998), Ozkan et al. (1998) and Machado et al. (1998) proposed different control strategies for reactor temperature control of a batch polymerization reactor. An obvious disadvantage of the conventional controller used in the review is that the system’s model must be well known before the control system can be developed. Thus, neural network, which is a data based method, may be an alternative for this modelling and control approach.

Artificial neural network is a “black-box” estimator where there is no attempt to interpret the model structure (Hussain, 1999; Hussain and Kershenbaum, 2000; Hussain et al., 2002). It is a universal function approximator that typically works much better in practical applications than most traditional and polynomial-based function approximations methods. It is only trained on the basis of data collected in simulation or in the laboratory to learn the mapping between various variables which can then be used as “virtual analyzers”. The usage of neural networks in polymerization systems is not a new topic.

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