Model-based optimization of the production of polyvinyl acetate

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Abstract

In the environment of increasing demand and competitiveness the polymer manufacturers need to augment the production at the lowest cost. This work will consider the polymerization plant in Mitol factory in Sežana, Slovenia, which is nowadays working over ninety per cent of its capacity. The main variables affecting the duration of the reaction and thus the productivity are: the temperature in the reactor, the initial amount of monomer, the subsequent feed rate of monomer and the addition of initiator (Lovel & El-Aaser (eds.), 1997). The preliminary analysis of the production process of polyvinyl acetate in Mitol revealed that during the reaction the temperature is controlled by manually adding the initiator. This can lead to the offset and oscillations of the reactor temperature, affecting both the final quality and the duration of the reaction. Furthermore, the ratio between the amount of monomer charged in the beginning and the amount charged during the reaction is feasible, but has never been optimised. Therefore, the possibilities to increase the production of polyvinyl acetate in Mitol are the enhancement of the temperature control through the optimal addition of initiator and the optimization of the monomer addition profile. The constraints imposed on the objective function consider the desired final conversion and particle size of the polymer product. Since the real plant cannot be used to perform experiments a model has been developed on which the optimization algorithms can be applied.

Emulsion polymerization of vinyl acetate is a deeply studied process. Efforts have been made to determine its kinetics (Chern and Poehlein, 1987; Urquiola et al., 1992) and to develop an integral mathematical model of the process (Urquiola et al., 1992; Gilmore et al., 1993; Asteasuain et al., 2001; Araújo and Giudici, 2003). However, the validation of these models has been made through small-scale laboratory experiments, which makes them unreliable when estimating the characteristics of the product in a real scale reactor. This is mainly due to the uncertainty introduced by the manual operations and the variability in the operator actions to control the reactor temperature.

In the polymerization plant in Mitol the prescribed recipe for polyvinyl acetate production is followed. The recipe specifies the initial amounts and types of raw materials and the feed rate of the remaining monomer. Besides the recipe, the production is influenced by the operators' actions. During the polymerization the operators have the responsibility to decide when to add more initiator, and when to start the addition of monomer.

The optimization of the polyvinyl acetate production has been developed using the the model of the reaction previously developed in gPROMS. The four main variables identified by the Mitol company as characteristic for the final product quality: the final conversion, particle size, solids content and viscosity, act as the end point constraints. The maximum temperature in the reactor conforms the path constraint. The initial amount of monomer, the

subsequent flow rate of monomer, and the addition of initiator are the model inputs that will be manipulated by optimization.

In this paper the optimal monomer and initiator addition flow rates are calculated. The objective of the optimization is the reduction of the time of the reaction and the constraints, the maximum temperature and quality variables.

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