ABSTRACT

Emulsion polymerization involves nucleation and growth of particle nuclei, followed by consumption of residual monomer in a heterogeneous reaction system. The propagation reaction of free radicals with monomer molecules takes place primarily in the latex particles and the emulsified monomer droplets only serve as a reservoir to supply the growing particles with monomer. Polymerization in non-uniform latex particles is a potential candidate for offering various application properties. Emulsion polymerization has huge application in industries of textile, paint and pharmaceutical.

Only a small number of industries uses large scale batch reactor for production of polymer. However, from batch emulsion polymerization reactor, we can produce narrower distribution of particles, higher molecular weight and can get higher rate of polymerization as compared to that of semi-batch and continuous reactor.

To study the end-use properties of the polymer we developed models for molecular weight distribution and particle size distribution. The moment equations are utilized to find molecular weight distribution, and average molecular weight. The model for the particle size distribution is taken from literature (Crowley, Meadows et al. 2000). Zero-one model was selected for the study, the particles are assumed to contain either one or zero radical. In such a system, the average number of radicals per particle cannot exceed 0.5. Termination occurs only between an entering radical and a growing radical.

Batch reactor was used for the experiments in the laboratory. The experiments were carried out in a reaction vessel maintained at 70ºC. The reactor contents were agitated using impeller at 750 rpm. The impeller was connected to a variable speed motor, thus allowing changing the speed of the agitator. Vessel contains the thermocouple to monitor the temperature of the reaction mixture with on/off control system. Prior to start the reaction, the reactor was purge with nitrogen gas to dissipate the oxygen, if present. A nitrogen blanket was maintained throughout the reaction. A reliable apparatus Malvern Mastersizer 2000E was used to study particle size

distribution and monomer droplets size. The system operates on scattering pattern of light. Samples are added to the unit and circulated after sonication, distilled water was used as dispersant. Different concentrations of monomer, initiator and surfactant were used in analysis for particle size distribution and molecular weight.

As the polymerization reactors are exothermic and reactor thermal runaways can occur, effective control strategies have to be implemented. Here, we have made an attempt to develop three control systems for batch reactor viz. PID, MPC and NNPC.

A simulink model was developed for batch reactor using PMMA for the study. In this study, two different strategies were used for PID to control the temperature of the reactor. First PID controller used split range and second PID uses heater power as manipulative variable. We, further, pursue with model predictive control and neural network control. The molecular weight and PSD of the polymer are the most important elements to the properties of the product. However it is difficult to measure the molecular weight or PSD in real time. Therefore, the control of the molecular weight and PSD is often carried out by controlling the reaction temperature.

To make the quantitative comparison of the controllers, performance criteria for good control action were applied. These are the integral of time weighted absolute error (ITAE), integral of the square of the error (ISE), the integral of the absolute of the error. This helped in obtaining insights on aspects of simulation. All the criteria were analysed carefully and the model validation was done with experimental data. Nitrogen gas is used during the process, as the viscosity increases probability of entrapment of gas bubbles increases. A model is introduced in this work and simulated using MATLAB.