ABSTRACT

The work in this thesis concerns with the betterment of the control in processes, which are highly nonlinear. The processes considered are Continuously Stirred Tank Reactor (CSTR) pH and Inline-pH process. The work is aimed at development of a suitable Artificial Neural Network (ANN) model and test its capability in the control of non-linear processes as compared with the conventional methods of control. An Internal Model Control (IMC) framework has been chosen as the control strategy. Developed techniques are tested and verified for their efficacy on both simulated processes and the real life processes.

The inherent non-linearity of pH-processes poses the major difficulty to control them. In case of the Inline-pH process, this non-linearity is severe and unpredictable. Classical linear feedback control does not guarantee the satisfactory performance in such situations. Of late, the IMC scheme has been in wide use in process control. This is due to its good disturbance rejection capabilities and robustness.

The mathematical models of the CSTR-pH process and Inline-pH process are obtained. The models so obtained are used for generating simulated input-output data of the processes. Further, the neural network model of these processes is obtained. This ANN modeling involves the design of experiment for data collection, model structure selection, estimation and validation of the model.

Inline-pH process is modeled using basic CSTR model and transportation delays. The dynamics of the Inline-pH process are more complicated than CSTR-pH process. The multilayer perceptron neural network is used for the modeling of the processes. The study also involves the various issues like selection of input signal, sampling time, model order testing and model verification. The prediction accuracy of neural network based process models is also evaluated. Inverse process models of the processes have been obtained.

The specific significance of the contribution of this work is to establish the effectiveness of artificial neural networks in model-based control. The ANN-IMC control scheme is implemented by means of identified forward and inverse models. The regulator and servo behavior of the control scheme in tested with simulated processes. The performance of control scheme is compared with two benchmark controllers, namely, PID and feed forward-feedback controller. The robustness of the ANN-IMC controller has been verified by testing the regulatory performance of ANN-IMC controller for the disturbances, which are not considered while training of the inverse model.

For disturbance rejection, addition of the ANN-IMC controller to the conventional PID controller can enhance the controller performance. In this context, a control strategy is proposed as, Additive Internal Model Control (AIMC). This scheme is based on the two strategies viz. Additive feed forward control (AFC) and Internal Model Control. The proposed scheme seeks to use ANN-IMC controller in the form of additive feed forward control along with conventional PID controller to improve the overall performance.

The disturbance rejection performance of AIMC controller is better than all conventional benchmark controllers. The control actions taken by the feed forward controller are much quicker. This was expected as the controller reacted immediately to the measured disturbances. This fact has been verified at different set points in the operating region. The studies on the performance of the AIMC controller for the non-constant disturbances reveal that controller response to corrective action is very quick and causes very small oscillations at the output.

Experimental results using a laboratory setup test plant prove the effectiveness of the proposed control scheme.

Keywords: Artificial Neural Networks (ANN), Internal model control (IMC), Additive internal model control (AIMC), Nonlinear systems.