CHAPTER 5

5. CONCLUSIONS

The present study focused on PID tuning and control of the processes which are difficult to control using conventional control techniques. Direct synthesis and IMC based PID were designed and performance of the controller was evaluated in terms of response time, settling time and different error indices. The performance of the proposed PID controllers were compared with similar recently developed PID tuning methods.

The present work was divided mainly into four sections; the first section discussed the performance comparisons of different PI tuning methods existing in the literature and present PI controller designed by computational optimization techniques, applied to linear (second order transfer function), nonlinear and FOPDT model of the process. Second section discussed about the design of PID controller using direct synthesis for stable second order time delay transfer function (SOPDT) model and simulation studies of different SOPDT system using proposed tuning method. The third section discussed the PID design based on internal model control (IMC) technique for unstable second order time delay (USOPDT) and simulation studies of different process models using proposed method. The fourth and last section of this work discussed the temperature control of bioreactor using proposed IMC-PID controller for USOPDT.

The following conclusions can be drawn on the basis of present work.

(i) The comparative study of control behavior of linear and nonlinear models of CSTR clearly indicated that nonlinear model of CSTR provide better closed-loop results using PI controller designed by using different PI tuning methods, in terms of various performance measures. Among all three PI tuning methods, SIMC provided better close loop results than other tuning approaches in all three cases i.e. linear, nonlinear and FOPDT models. Therefore, these tuning techniques are expected to work well on real-time systems. The computational optimization technique used for finding of PI parameters for second order transfer function model of the CSTR worked well to all of linear, nonlinear and FOPDT models of CSTR for controlling the outlet concentration at desired level.

(ii) The conventional methods of PID tuning does not work well in case of process having second order dynamics with time delay (SOPDT). To overcome this problem, DS based PID controller was designed for SOPDT and applied on six different forms of FOPDT and SOPDT models. The performance of proposed PID tuning method was evaluated and found satisfactory for all models. Overall results were found better than results obtained by previous work.

(iii) Many chemical and biochemical processes show unstable second order dynamics with time delay (USOPDT). Controlling of such processes using PID tunned with conventional technique is very challanging and most of the time provide unsatisfactory performance. In the present study, IMC-PID controller based on maximum sensitivity (*Ms*) was designed for unstable second-order

time delay (USOPDT) model with inverse response characteristics (RHP zero) and its performance was evaluated for different forms of second-order time delay processes. The results show the satisfactory performance of proposed PID controller. The closed-loop results also indicated better performance of proposed method as compared to methods provided by other workers.

(iv) Temperature is one of the most crucial process parameter in fermentation process. Good temperature control provide better yield and quality of the product. However, control of temperature is very challanging due to unstable nature of fermenter. IMC technique was used to design PID controller and used successfully to control the temperature of bioreactor in fermenter. The close-loop results were better than results obtained by many previous workers for the same process.

The above results clearly indicated that the properly tunned PID controller may provide solutions to the most of the control related problems in the process industries.