CHAPTER 7

CONCLUSION

7.1 CONCLUSION

In this research work, conventional, intelligent, heuristic and advanced controllers are designed and implemented, for a FOPDT nonlinear heat exchanger. The merits and demerits of each controller scheme are discussed. The performance analyses of these controllers are validated based on the time domain specifications. Further, the best controller schemes for the considered specifications are obtained.

Initially, the controller objectives are obtained, using the classical PID controller. The feedback controller is analysed at 35%, 50% and 65% operating points, which provides effective control for the considered FOPDT process. It is observed that at various operating points, the ISE and IAE shown a decrease for an increase in the set point, for both the servo and regulatory problems. Similarly, the error increases if the set point is reduced. Any large shift in the operating points, without changing the tuning parameters, leads to instability. Hence, the process output near the high region is sluggish, which is further improved by using the FF-FBC.

An improved disturbance rejection is obtained using the FF-FBC, since there is no deviation in the regulatory response, which is due to the perfect FOPDT model developed. The constraints in designing the FF-FBC with K, τ, and K - τ considered, provide less deviation in the process output, compared to the FBC. Hence, the FF-FBC is sensitive to modelling errors.
Even though, the FF-FBC is very effective in eliminating the effects of the modelling errors, and provides better regulatory response, there is a need for improving the practical implementations. Model uncertainties and disturbance effects are addressed, using the NNFFC. It improves the process output with the best rise time and less settling time, without design modifications.

In particular, to obtain a robust control based on an accurate model of the process, the IMC is designed. The result shows that the IMC is sensitive to modeling errors, which gives superior performance for the considered FOPDT. The performance of the IMC in load disturbance rejection is further improved by a filter based design. The IMC-PID is realized, by inhibiting the features of the IMC to produce robust and control performances. The drawback of the IMC–PID method, which is only applicable to a specific type of FOPDT, is overcome by introducing fuzzy based intelligent controllers.

The knowledge based FLC improves the speed of the response for the FOPDT process significantly, compared to the SPWC. The drawbacks of the ZNSPWC are analyzed and validated, by the considered time domain specifications. The FSPWC for the ZN tuned process, eliminates the oscillations, thereby resulting in the overall performance of the system. Subsequently, the FSPWC designed for the IMC-PID improves the time domain specifications, compared to the FSPWC tuned ZN. In addition, the IFLC is implemented with the FBC, without hardware modifications. Further, the performance enhancement is confirmed by the time domain specifications.

The effect of the disturbance of the considered process is addressed with the ADRC, by the combination of the ESO with the traditional PD controller. The performance of the controller is improved significantly,
compared to that of the conventional controllers. This controller shows no occurrence of overshoot and its after-effects. Further, it attains a swift settling time and estimates disturbances quickly and accurately, which provides less rise and settling times. Thus, the advanced ADRC proves to be a better controller compared, to conventional and intelligent controllers.

An attempt has been made to implement heuristic techniques to arrive at an optimal controller parameter, using the PSO, BFO and Hybrid in combination with the BF-PSO. The PSO, BFO and hybrid algorithms based PID controllers are compared, with the PID and IMC based PID controllers, which provide better performance in terms of the rise time, peak time, settling time, ISE and IAE. Optimization based controllers reduce the ISE and IAE values, which improves the efficacy of the system.

The work focuses mainly on the FOPDT system, which can be further applied to any nonlinear system.

The contributions of this research work are summarized below:

- The FOPDT model of the heat exchanger system has been developed with less model mismatch.
- The FBC, FF-FBC and IMC controllers are designed for the FOPDT process to perform under model mismatch.
- The NNFFC is designed for effective load disturbance rejection.
- The IFLC proves the servo and regulatory operations of the process under model mismatch.
- The ADRC is effectively implemented for the FOPDT for set point tracking and disturbance rejection.
- Heuristic algorithms are applied to find the optimum controller parameters, and to enhance the performance of the system.

In this work, the FOPDT model of the heat exchanger is identified, using the PRC method. The closed loop performance of the conventional controller tuning procedures, such as the FBC, FF-FBC, SPWC and IMC are compared with the FLC, ADRC, and Heuristic ones. The ADRC method provides improved performances such as smooth reference tracking with reduced peak overshoot, reduced settling time, and reduced error measure in the servo and regulatory responses, for the FOPDT process considered in this work.

7.2 SCOPE FOR FUTURE WORK

The performance analysis of the attempted control techniques can be carried out for SOPDT, stable and unstable systems.

The stability analysis of the ADRC can be implemented, with and without plant model information. Predictive ADRC can be developed for the processes with time delay, to maintain good transient response and robustness.

The performance of heuristic algorithms like the Firefly algorithm and Bat algorithm can be analysed. The performance of heuristic algorithms can be tested in real time with modified objective functions.