Chapter 7

Conclusions and future scope

7.1 Conclusions

The presented work addressed the design of FOPID controller and optimization of their parameters. In this concern, initially classical PID controller has been designed using ZN-technique in MATLAB. The parameters of ZN-PID controller has been considered as starting values of parameters ($i.e.\ K_P, K_I,$ and K_D) of FOPID controller. Starting values of fractional power of integral and differential terms ($i.e.\ \lambda$ and μ) has been chosen randomly. Approximation of fractional term has been done using Oustaloup's recursive approximation using FOMCON toolbox in MATLAB.

The FOPID controller has been designed for various problems like: third order linear system, time-delayed systems, magnetic levitation system, DC-buck regulator system, spherical tank system and AVR-system. Parameters of FOPID controller designed for each system has been optimized using three techniques NM-algorithm, GWO-algorithm and MGWO-algorithm.

The FOPID controllers designed using NM-algorithms has depicted improved the performance of the systems than the classical ZN-PID controller but in most of cases it failed to fulfil the design requirements of the systems. Examples for the case of third order linear plant, time-delayed systems and AVR system. Moreover, it has depicted a huge percentage overshoot in case of time-delayed system, and AVR system.

Further, the GWO-algorithm has shown an impressive performance by presenting an effective and superior controller than NM-FOPID. The GWO-FOPID controller designed for third order linear plant, time-delayed systems, magnetic levitation, DC-buck

regulator, spherical tank and AVR system has showcased better results than ZN-PID, NM-FOPID and other controllers present in the literature.

Lastly, MGWO-algorithm has been presented to optimize the parameters of FOPID controllers designed for same systems. For most of the systems discussed in this work, it has presents better FOPID controller than ZN-PID, NM-FOPID, GWO-FOPID and other PID and FOPID controllers present in the literature. Fulfilling all the design requirements it has improved both the time-domain as well as frequency domain performance of the systems. In case of third order linear plant and DC-buck regulator, the performance of the MGWO-algorithm has degraded where GWO-algorithm has presented superior controller than this.

Validation of results has been done by comparing the step responses of the proposed controllers with the existing controllers in the literature. The comparison shows the superior performance of the MGWO-algorithm over the other proposed and existing controllers.

7.2 Future scope

The above depicted conclusions of the present work unwraps an arena for the options of the future scope that can be pursued in further studies in this field. Here enumerated are fewer domains where the work can be extended for designing the FOPID controller;

- Multi-variable systems,
- Non-linear systems,
- Complex systems,
- Discrete-time systems.

Additionally, the parameters obtained through various optimization techniques can be implemented on the practical models available for systems considered in the examples of the present work.

At this point, the proposal of an appreciable design of the FOPID controller parameters concludes the thesis *Design of Fractional Order PID Controller and their Parameter Optimization*. The anticipation of this work is contributed towards the control community.