ABSTRACT

Recently, various techniques are implemented in the field of control engineering to control the plants or system as per the user requirement. Day by day, new methods are evolving to get better quality of controller for different process or plants in terms of high quality of products and performance. Despite advances in control methods, still the Proportional-Integrator-Derivative (PID) controller is frequently used in the process control area because of its proven advantages such as simple structure and easy to implement. Further, frequent usage of conventional PID controller has motivated many researchers to achieve better design methods or advances in PID control structure. Now days, researchers give more focus on fractional order PID (FOPID) controller because of better closed loop performance and robustness features due to iso-damping property as compared to conventional PID controllers. The design of FOPID required two more extra parameters than the conventional PID i.e. λ and μ, where λ is the fractional order of integral term and μ is the fractional order of derivative term of FOPID. Basically, FOPID controller represents the generalized version of conventional PID controller. The most challenging task in the design of FOPID controller is to get proper controller parameters by using suitable tuning methods. In literature, there are various design methods for FOPID controller by using both conventional as well as meta-heuristic techniques. Currently, the researchers focus drive into the application of meta-heuristic methods in the design of FOPID controller.

In this thesis, the optimal designs of FOPID controller using meta-heuristic algorithms for different applications are studied using simulation. In this regard, the performance of the modern meta-heuristic techniques are evaluated by considering different applications such as Automatic Voltage Regulator system (AVR), 1st order delay system like heat flow system (HFS), Nonlinear cruise control system etc. The PID and FOPID controller based on the Ant Lion Optimization techniques for Automobile Voltage Regulator (AVR) system is proposed in the thesis. The proposed techniques are compared with existing techniques based on transient and frequency response. The proposed controllers for AVR system are observed to have better performance than the existing methods.

In the present work, another application of FOPID controller is introduced considering Heat Flow System (HFS). The tuning parameters of proposed FOPID controller for HFS are calculated by using the various meta-heuristics algorithms such as ALO, Grey Wolf Optimization (GWO), Moth Flame Optimization (MFO), Particle Swarm Optimization (PSO) and PSO-GSA algorithm and in addition a comparison is carried out in between these method's tuning parameters on the basis of both transient and frequency response.

The study of effective behavior of proposed PID and FOPID controller for a nonlinear Automobile Cruise Control (ACC) system is also carried out. The PID controller parameters are estimated by using ALO algorithm and the FOPID parameters are calculated by using 'FMINCON' solver toolbox. From simulation study, it has been observed that the proposed FOPID method performs better than the existing methods.

The work of this thesis is not only confined with the works discussed as above, but also it is expanded to design of FOPID controller for higher order system. The ALO is used to optimize the parameters of the FOPID controllers. The proposed controller has superiority value in terms of transient and frequency responses as compared with other methods, which has been demonstrated by illustrative examples.

Keywords:*Fractional order PID controller, Automatic Voltage Regulator System, Ant Lion Optimization, Heat Flow System, Grey Wolf Optimization, Moth Flame Optimization, Particle Swarm Optimization, Automobile Cruise Control System, Bode Reference Model, FOMCON, Transient Response, Frequency Response.*