ABSTRACT

Nowadays, the process industries are discharging a huge volume of the effluent and it has become as one of the biggest challenges for the conservation of the environment from the pollution. The presence of the hazardous chemicals and a large volume of the effluent make the textile dyeing industry as one of the most polluting industries affecting the surrounding environments. Hence, the textile wastewater treatment plants located in Tamil Nadu, India are strictly proceeding as Zero Liquid Discharge Plant to protect the environment from the discharge of the effluent. The textile wastewater treatment is a more complicated process due to its various stages and time-consuming process. The treatment process has three stages as namely Primary process, Secondary process and Tertiary process. In every stage, neutralization of pH is a very important process as a part of effluent treatment.

The coagulation process in the primary treatment and biological process in the secondary treatment are the most important process to reduce the significant percentage of Chemical Oxygen Demand, Bio Oxygen Demand of the effluent. The effective results of the treatment can be obtained from the above processes by controlling the pH of the effluent at the necessary operating points. However, control of the pH is very tedious due its nonlinear and time-varying characteristics.

PID controllers are widely used in the process industries due to its merits like simple structure, reliability, accuracy and effective setpoint tracking. In this present work, heuristic algorithm based Proportional-Integral controller has developed to control the pH of the textile effluent.
Bacterial Foraging Optimization Algorithm and Firefly Algorithm based heuristic algorithms are applied to tune the controller parameters such as proportional gain and integral gain. Genetic Algorithm and Particle Swarm Optimization technique have been implemented to design the PI controller for validating the result of the proposed BFO and FA based PI controllers.

A real time laboratory scale pH control system has been used to investigate the performance of the proposed controllers. The pH control system has represented as First Order plus Time Delay model using a transient step response analysis at three operating points of pH. The weighted sum of multi-objective function based optimization technique has adopted to compute the optimum controller parameters of the heuristic based PI controller.

In the first phase, the performances of the controllers have been investigated in simulation mode. In this analysis, the performance of the proposed BFO-PI controller has been tested with the conventional ZN method and GA based PI controllers. In addition, performance of the FA based controller is tested with the conventional Relay Feedback method and PSO based PI controllers. The set point tracking - servo response and regulatory response analysis have been conducted to evaluate the performance of the controllers. The error indices such as IAE, ISE, ITAE, ITSE and quality indices such as peak overshoot, rise time and settling time are also considered for the performance measure of the analysis.

In the second phase, the real time experimental analysis has been conducted using pH control system to study the performance of the heuristic algorithm based controllers. The synthetic solutions of 0.1 N strong acid HCL and 0.1 N strong base NaoH solution are used as chemical agents for the study. The analysis has indicated the efficacy of the proposed heuristic algorithm based PI controller in controlling pH at all operating points.
The effluent samples have been collected from a treatment plant at the stages of the coagulation process and biological process to investigate the performance of proposed controllers. In the final phase, the heuristic algorithm based controllers have been implemented to control the effluent of the textile industry in the pH control system. The investigation concludes that Firefly algorithm based PI controller has provided superior controller action for the pH control of the textile industry effluents.