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Tuning of PID Controller using Genetic Algorithm and Compare with Integral Errors in CSTR SYSTEM

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Abstract—*The paper present to design PID controller parameters for an cstr system using GA Algorithm. The design goal is to minimize the optimal parameters of the integral errors and reduce transient response by minimizing overshoot, settling time and rise time of step response. First an objective function is defined, and then by minimizing the objective functions using GA Algorithm. The CSTR system is very important equipment in chmeical and biochemical industry. Various control approaches have been applied on CSTR to control its parameters. We want to control concentration of chemical in CSTR system for Stability.*

Keywords: *CSTR system, Feedback System, GA, PID Controller.*

1. INTRODUCTION

To design a PID Controller for cstr system using GA algorithm. The model of a Continuous Stirred Tank Reactor modal is used as a plant. The main objective is to obtain a stable, robust and controlled system using GA. The CSTR system is modeled in Simulink and the GA algorithm is implemented in MATLAB. Comparing with Genetic algorithm and Particle swarm optimization (PSO) method, the proposed method was more efficient in improving the step response characteristics such as, reducing the steady-states error, rise time, settling time and maximum overshoot of a CSTR system. CSTR involves complex reactions with high nonlinearity, and it is very hard to be controlled by the conventional methods. However, to avoid computational complexity brought in by such nonlinear controller. GA Algorithm based PID controller tuning is attempted for the concentration control of Continuous Stirred tank reactor (CSTR). Based on the Performance indexes criterion controller can be estimated. The Integral Square Error (ISE) criterion is used to guide GA algorithm to search the controller parameters like Kp, Ki, Kd.Simulation is carried out with PID controller Structures. The comparison between PSO-based PID (PSO-PID) performance and the GA-PID is presented. CSTRs are very important equipment in the chemical and biochemical industry, offering a diverse range of researche in the area of the chemical and control engineering. Various control approaches have been applied on CSTR to control its parameters. Due to its strong non-linear behavior, the problem of identification and control of CSTR is always a challenging task for control system engineer [1].

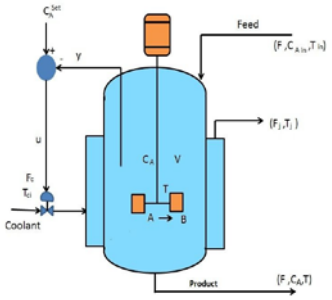

Fig. 1: CSTR system.

2. PROBLEM FORMULATION

The Project is objected to design a PID controller for Continuous Stirred Tank Reactor. The cstr system transfer function..

$$T(s) = \frac{-1.17s+3.1472}{s^2+4.6429s+5.3821}$$

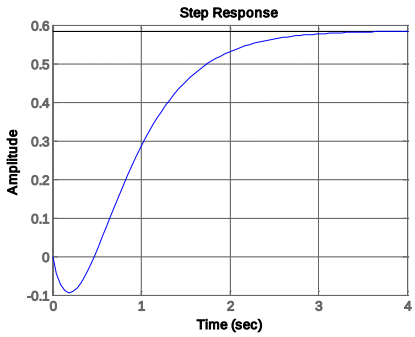

Fig. 2: Step Response of CSTR system

Table 1: Parameter of Step response of plant Without PID

Rise Time	Settling time	Undershoot
1.3744	2.7130	16.0688

3. PID CONTROLLER

Proportional-Integral Derivative (PID) controllers have been widely used for speed and position control of various applications. Among the conventional PID tuning methods, the Ziegler–Nichols method may be the most well known technique. For a wide range of practical processes, this tuning approach works quite well. However, sometimes it does not provide good tuning and tends to produce a big overshoot [2]. Therefore, this method usually needs retuning before applied to control industrial processes. To enhance the capabilities of traditional PID parameter tuning techniques, several intelligent approaches have been suggested to improve the PID tuning. In a PID controller, each mode (proportional, integral and derivative mode) has a gain to be tuned, giving as a result three variables involved in the tuning process. There have been a lot of approaches to search the parameters of PID controllers, including time response tuning, time domain optimization,frequency domain shaping ,The speed response of the drive with PID controllers designed with the above techniques may be satisfactory but not necessarily be the best, since they do not pose any constraint on settling time, overshoot / undershoot etc.

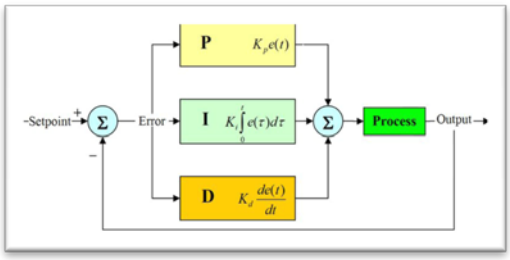

Fig. 3: PID Controller

PID is a feedback based controller which gets the error value and calculates the output based on the characteristics of the error. it is widely used in plants as it is simple and gives good result.PID is used in a closed loop .it has three elements P ,I ,D. Every parameter has gain by which we control the contribution. Proportional-Integral Derivative (PID) controllers have been widely used for speed and position control of various applications. Among the conventional PID tuning methods, the Ziegler–Nichols method may be the most well known technique. For a wide range of practical processes, this tuning approach works quite well. However, sometimes it does not provide good tuning and tends to produce a big overshoot.

4. GA ALGORITHM

A genetic algorithm (GA) is a local search technique used to find approximate solutions to optimization and search problems. Genetic algorithms are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover (also called recombination).Genetic algorithms are typically implemented as a computer simulation, in which a population of abstract representations (called chromosomes) of candidate solutions (called individuals) to an optimization problem evolves toward better solutions [3]. The evolution starts from a population of completely random individuals and occurs in generations. In each generation, the fitness of the whole population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (mutated or recombined) to form a new population. The new population is then used in the next iteration of the algorithm.

Flow chart Of Genetic Algorithm Process

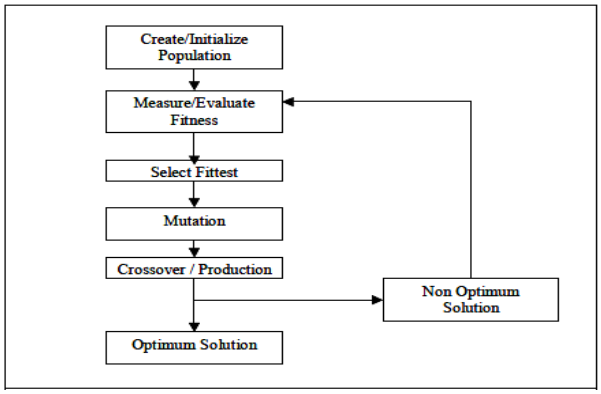

Fig. 4: Genetic Algorithm Process Flowchart

5. PERFORMANCE EVALUATION CRITERIA

Quantification of system performance is achieved through a performance index. The performance selected depends on the process under consideration and is chosen such that emphasis is placed on specific aspects of system performance. Furthermore, performance index is defined as a quantitative measure to depict the system performance of the designed PID controller. Using this technique an 'optimum system' can often be designed and a set of PID parameters in the system can be adjusted to meet the required specification. For a PID-controlled system, there are often four indices to depict the system performance: ISE, IAE, ITAE They are defined as follows:

$$ISE = \int_0^\infty e^2(t)\,dt$$

IAE Index:

IAE = $\int_0^\infty |e(t)|\,dt$

ITAE Index:

ITAE = $\int_0^\infty t|e(t)|\,dt$

6. SIMULATION AND RESULTS

Transfer function of CSTR system:

$$T(s) = \frac{-1.17s + 3.1472}{s^2 + 4.6429s + 5.3821}$$

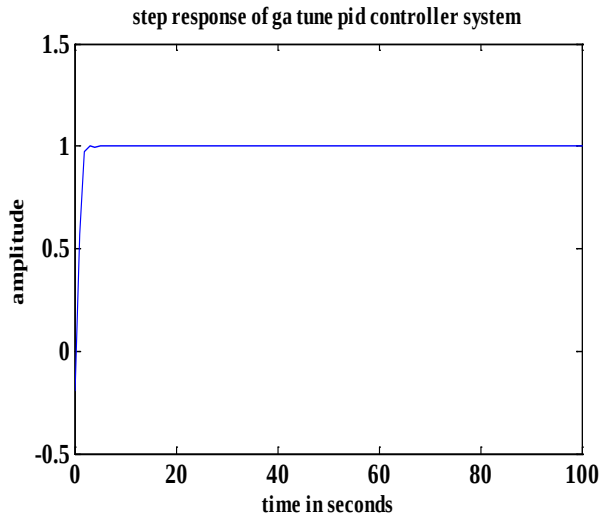

Fig. 5: Step Response of PID Controller Using GA Algorithm

Table 2: Parameter of Step response of plant with PID

Rise Time	Settling Time	Overshoot	Undershoot
1.2440	2.0262	0	19.3081

Table 3: Parameter gain of GA Algorithm Tuned PID control system

kp	Ki	kd
1.2172	1.6139	0.1429

7. CONCLUSION

- The tunable results obtained are compared with the un-tunable results obtained from GA algorithm. This comparison shows that there is an acceptable agreement between these results.
- We can see from the results that there is error between step response of PID controller of CSTR system. To reduce error we apply the GA algorithm. We design the PID controller parameters for CSTR system.
- We observe the system performance of PID controller of CSTR system.

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