Spvryan's International Journal of Engineering Sciences & Technology (SEST)
ISSN : 2394-0905

Designing & Optimization of the Controller Parameters for CSTR System using Particle Swarm Optimization

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Abstract— **This paper presents Designing & Optimization of the Controller Parameters for CSTR (Continuous Stirred Tank Reactor) system using Particle Swarm Optimization. We are using here isothermal continuous stirred tank reactor that is one of the types of reactor which operates at a constant temperature. The author developed a mathematical model of the isothermal CSTR [1] The primary goal of the controller is to control the product concentration of isothermal CSTR while manipulating the input flow rate. This paper designs a PID controller then tunes the PID controller's parameters using PSO (particle swarm optimization) technique. It is observed that if we use the PSO, PID controller performs best output results to control the concentration of isothermal continuous stirred tank reactor.**

Keywords— **CSTR, PID, PSO**

I. INTRODUCTION

PID controllers are most widely used controllers in past two decades. There are many tuning methods available and most of the PID controller tuning uses frequency response methods for example Zeigler-Nichols rule, symmetric optimum rule, Cohen-Coon tuning, internal model control, ITAE tuning rules etc. These tuning rules provide a simple way to calculate the parameters of PID controllers. But in most of the cases, it doesn't provide satisfactory closed loop performance. For this, we used PSO. It optimizes the parameter of PID controller and give the best result.

The widespread use of chemical reactors has led to design of different control mechanism to control different parameters of the reactor. The control mechanism can be a conventional control or an intelligent control. This paper considers an isothermal CSTR [1] and models the system to obtain the state space and transfer function model of the system. The primary objective of the control mechanism developed for the isothermal CSTR is that the product concentration should be controlled irrespective of the different disturbances and delays. To obtain this control mechanism, conventional and intelligent controller is developed.

II. NOMENCLATURE

CSTR	Continuous Stirred Tank Reactor
A	Cyclopentadine
B	Cyclopentenol
C	Cylcopentanediol
D	Dicyclopentadiene
k_1	Rate constant for $A \rightarrow B$ $\left(\min^{-1}\right)$
k_2	Rate constant for $B \rightarrow C$ $\left(\min^{-1}\right)$
k_3	Rate constant for $2A \rightarrow D$ $\left(mol/l - \min\right)$
r_A	Molar rate of formation of A
r_B	Molar rate of formation of B
r_C	Molar rate of formation of A
r_D	Molar rate of formation of A
C_A	Concentration of A
C_B	Concentration of B
C_{As}	Steady state concentration of A
C_{Bs}	Steady state concentration of B

III. CHEMICAL REACTOR

A chemical reactor is a device which is used to contain controlled chemical reactions. Reactions take place inside the reactor, in conditions which can be monitored and controlled for safety and efficiency [2]. Chemical reactors can be used as either tanks or pipes, depending on the needs, and they can vary in size considerably. Chemical reactors can be classified according to different properties

1. Reaction phase
2. Operating modes

1. **Reaction Phase:** In industrial chemical processes, Phase reactors have a wide range of applications such as oxidation, hydrogenation, hydro-desulfurization. According to the reaction phase, chemical reactor can be classified as [3]:

(a) Homogeneous reactor
(b) Heterogeneous reactor

(a) **Homogeneous reactor:** one phase such as gas or liquid exists in the reactors.

(b) **Heterogeneous reactor:** Two distinct phases of reactants (or catalyst) coexist.

2. **Operating modes:** According to the operating modes, chemical reactors can be classified as batch, semi batch, or continuous modes.
    1. Continuous stirred tank reactor
    2. Batch stirred tank reactor
    3. Semi batch

When a reactor is operated in a **batch mode**, the reactants are charged, and the vessel is closed and brought to the desired temperature and pressure. In a **semi batch reactor operation**, one or more reactants are in the batch mode, while the co-reactant is fed and withdrawn continuously. In a chemical reactor designed for **continuous operation**, there is continuous addition to, and withdrawal of reactants and products from, the reactor system [2][4],

While designing a chemical reactor following factor has to be considered, (i) Overall size of reactor, (ii) Products emerging from reactor, (iii) Temperature inside the reactor (iv) Pressure inside the reactor (v) Rate of reaction (vi) Activity and mode of catalyst (vii) Stability and controllability of reactor.

IV. ISOTHERMAL REACTOR & MODELLING

Isothermal CSTR is a type of CSTR which is operating at a constant temperature. The volume is also assumed to be constant. The reaction scheme consists of the following irreversible reactions. The feed stream contains only component A. The isothermal CSTR has following reaction scheme which is called Van de Vusse reaction.

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

$$2A \xrightarrow{k_3} D$$

For the above reaction the values of rate constant are

$$k_1 = 50h^{-1} = 0.83\min^{-1}$$

$$k_2 = 100h^{-1} = 1.66\min^{-1}$$

$$k_3 = 10moll^{-1}h^{-1} = 0.166moll^{-1}\min^{-1}$$

Steady state feed concentration is $C_{Afs} = 10gmoll^{-1}$

Overall material balance is given as

$$\frac{d\left(V\rho\right)}{dt} = F_i\rho - F\rho \qquad (1)$$

So, $F = F_i$ (2)

Where ρ= liquid-phase density,
V = volume,
F = Volumetric flow rate.

Component material balance can be shown as

$$\frac{d\left(VC_A\right)}{dt} = F\left(C_{Af} - C_A\right) - Vk_1C_A - Vk_3C_A^2 \qquad (3)$$

Simplifying eq (3) we obtain eq (4)

$$\frac{dC_A}{dt} = \frac{F}{V}\left(C_{Af} - C_A\right) - k_1C_A - k_3C_A^2 \qquad (4)$$

$$\frac{dC_B}{dt} = -\frac{F}{V}C_B + k_1C_A - k_2C_B \qquad (5)$$

Where C_A, C_B are the concentration of A,B respectively and k_1, k_2, k_3 are the reaction rate constant.

$$\frac{dC_C}{dt} = -\frac{F}{V}C_C + k_2C_B \qquad (6)$$

$$\frac{dC_D}{dt} = -\frac{F}{V}C_D + \frac{1}{2}k_3C_A^2 \qquad (7)$$

These modelling equations assume a constant volume. The equations for C_C and C_D are neglected because C_B is not dependent on them.

The molar rate of formation for each component (per unit volume) is

$$r_A = -k_1C_A - k_3C_A^2 \qquad (8)$$

$$r_B = k_1C_A - k_2C_B \qquad (9)$$

$$r_C = k_2C_B \qquad (10)$$

$$r_D = \frac{1}{2}k_3C_A^2 \qquad (11)$$

Solving eq(4) and eq(5)

$$-k_3C_{As}^2 + \left(-k_1 - \frac{F_s}{V}\right)C_{As} + \frac{F_s}{V}C_{Afs} = 0 \qquad (12)$$

Steady state concentration of A and B is defined as

$$C_{As} = \frac{-\left(k_1 + \frac{F_s}{V}\right)}{2k_3} + \frac{\sqrt{\left(k_1 + \frac{F_s}{V}\right)^2 + 4k_3\frac{F_s}{V}C_{Afs}}}{2k_3} \qquad (13)$$

$$C_{Bs} = \frac{k_1C_{As}}{\frac{F_s}{V} + k_2} \qquad (14)$$

The linear state space model is represented as

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

The state variable is represented as

$$x = \begin{bmatrix} C_A & -C_{As} \\ C_B & -C_{Bs} \end{bmatrix}$$

The output variable is represented as

$$y = \left[C_B \;\; -C_{Bs}\right]$$

The input variable is represented as

$$u = \begin{bmatrix} \frac{F}{V} & \frac{F_s}{V} \\ C_{Af} & C_{Afs} \end{bmatrix}$$

Two dynamic functional equation is represented as

$$\frac{dC_A}{dt} = f_1\left(C_A, C_B, \frac{F}{V}\right) = \frac{F}{V}\left(C_{Af} - C_A\right) - k_1 C_A - k_3 C_A^2$$

$$\frac{dC_B}{dt} = f_2\left(C_A, C_B, \frac{F}{V}\right) = -\frac{F}{V} C_B + k_1 C_A - k_2 C_B$$

The elements of state space A matrix is found by

$$A_{ij} = \left.\frac{\partial f_i}{\partial x_j}\right|_{x_s, u_s}$$

The elements of state space B matrix is found by

$$B_{ij} = \left.\frac{\partial f_i}{\partial u_j}\right|_{x_s, u_s}$$

The state space model is represented as

$$A = \begin{bmatrix} -\frac{F_s}{V} - k_1 - 2k_3 C_{As} & 0 \\ k_1 & \frac{F_s}{V} - k_2 \end{bmatrix}$$

$$B = \begin{bmatrix} C_{Afs} - C_{As} & \frac{F_s}{V} \\ -C_{Bs} & 0 \end{bmatrix}$$

$$C = \begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$D = \begin{bmatrix} 0 & 0 \end{bmatrix}$$

Based on steady state operating point $C_{As} = 3 gmoll^{-1}$,

$C_{Bs} = 1.117 gmoll^{-1}$, $\frac{F_s}{V} = 0.5714 \min^{-1}$

$$A = \begin{bmatrix} -2.4 & 0 \\ 0.83 & -2.23 \end{bmatrix}$$

$$B = \begin{bmatrix} 7 & 0.57 \\ -1.117 & 0 \end{bmatrix}$$

$$C = \begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$D = \begin{bmatrix} 0 & 0 \end{bmatrix}$$

Converting the state space model to transfer function

$$G(s) = C\left(sI - A\right)^{-1} B$$

$$g_p(s) = \frac{-1.117s + 3.1472}{s^2 + 4.6429s + 5.3821} \qquad (15)$$

$$g_p(s) = \frac{-1.117s + 3.1472e^{-0.05s}}{s^2 + 4.6429s + 5.3821} \qquad (16)$$

$$g_d(s) = \frac{0.4762}{s^2 + 4.6429s + 5.3821} \qquad (17)$$

Eq (15) represents the process transfer function, eq (16) represents the process transfer function with delay and eq (17) represents the disturbance transfer function [1].

V. CONVENTIONAL CONTROL OF REACTOR

Control of isothermal CSTR has generated a lot of research interest and a large number of literatures can be found in this area. Some of the research findings are discussed in this section.

Jose Alvarez-Ramirez et.al presents proportional-integral (PI) control of continuously stirred tank reactors (CSTR). The main ingredient in the formulation is the use of a novel PI control configuration derived from modeling error compensation ideas. The main theoretical contribution is a novel stability analysis of a wide class of CSTR. It is shown that the performance of an inverse dynamics feedback control can be recovered by classical PI control. This performance recovery includes the region of attraction and transient response [5].

Nina F. Thornhill et.al presents the simulation of CSTR. In this article, volumetric and heat balance equations are presented along with algebraic equations derived from experimental data for calibration of sensors and actuators and unknown quantities such heat transfer through the heating coils. Many of these relationships have nonlinearities, and hard constraints such as the tank being full are also captured. A valuable feature is that the model uses measured, not simulated, noise and disturbances and therefore provides a realistic platform for data-driven identification and fault detection [6].

J Prakash et.al has presented a design criterion for nonlinear PID controller and non linear model predictive controller for a CSTR system which exhibits dynamic nonlinearity [7].

R Suja Mani Malar et.al has propsed the use of Artificial Neural Network to model and control the CSTR [8, 9].

In this research paper, the primary control objective is to control the product concentration of isothermal CSTR by varying the rate of dilution of the feed flow. The schematic diagram of the feedback control loop of isothermal CSTR is shown in figure 1.

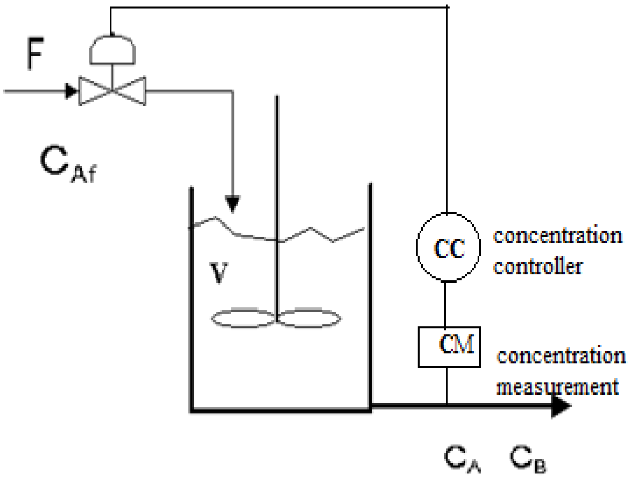

Figure 1: Feedback control mechanism for concentration control of isothermal CSTR.

Here CM represents the measurement of concentration and CC represents the concentration controller. Figure 2 shows the block diagram approach of feedback control scheme.

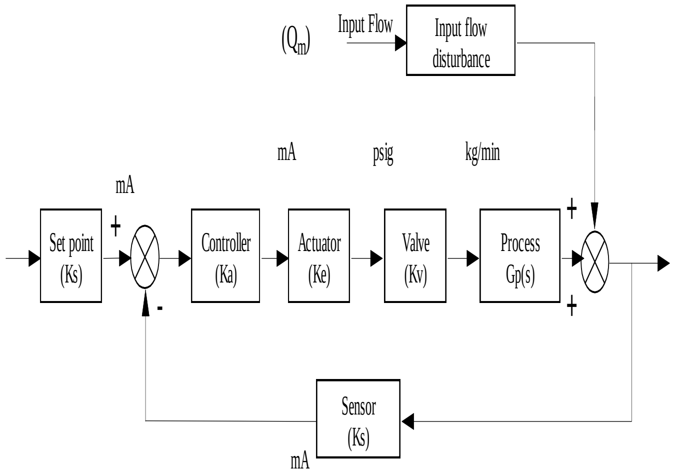

Figure 2: Block diagram based feedback control approach for concentration control of isothermal CSTR

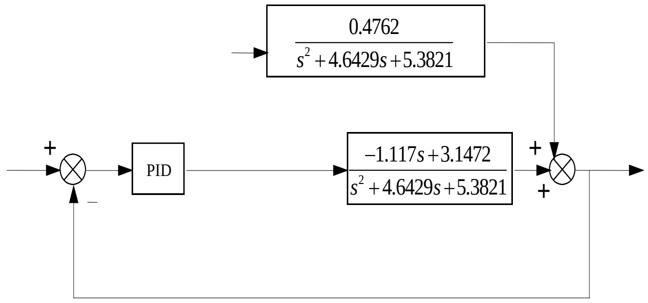

Figure 3: Transfer function based feedback control approach for concentration control of isothermal CSTR

Figure 3 shows the transfer function model of the feedback control scheme for concentration control of isothermal CSTR [10]. The transfer function for process and the disturbance is derived in section IV. Ideal PID controller in continuous time is given as [11]:

$$u(t) = K_c\left(e(t) + \frac{1}{\tau_i}\int_0^t e(t)dt + \tau_d\frac{de(t)}{dt}\right)$$

The PID controller is tuned using Zeigler-Nichols criteria of tuning [12]. In the above table 3.2, proportional gain, integral time and derivative time for different controller types are derived using ultimate gain and ultimate period using Ziegler-Nichols method.

Table 3.2: Ziegler Nichols Method

PID Type	**K_p**	**T_i**	**T_d**
P	$0.5K_{cr}$	∞	0
PI	$0.45K_{cr}$	$\frac{P_{cr}}{1.2}$	0
PID	$0.6K_{cr}$	$\frac{P_{cr}}{2}$	$\frac{P_{cr}}{8}$

The unit step response of feedback control is shown in figure 4. The values of proportional gain, integral gain and derivative gain of PID controller are 0.2, 0.95 and 0.23 respectively.

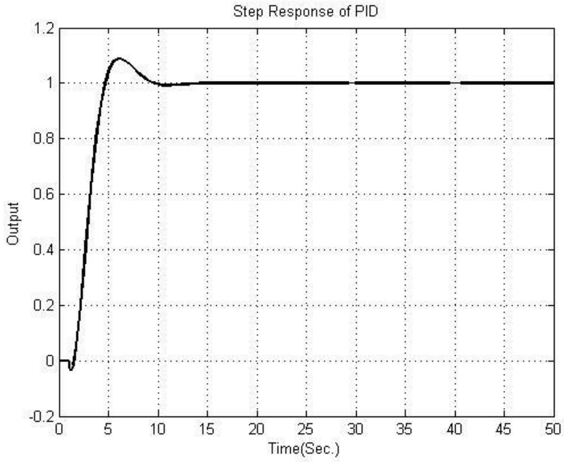

Figure 4: Unit step response of PID controller for concentration control

Figure 4 represents the unit step response of PID controller Figure 5 shows the unit step response of feedback control scheme with a disturbance. Due to this disturbance, the peak overshoot increases.

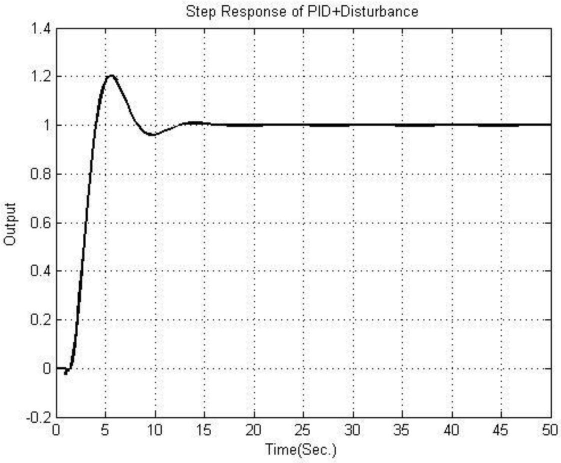

Figure 5: Unit step response of PID controller with disturbances

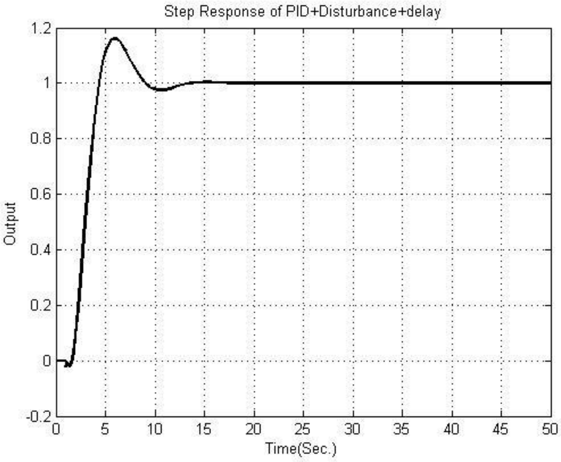

Figure 6: Unit step response of PID controller with delay and disturbances.

For the best optimal solution, we are using PSO (Partical swarm optimization) here. We tune the PID controller and optimize the parameter of PID controller using PSO. For this, we make the simulink model of PID controller for the different iteration M= 10, 15, 20, 25, 30, 40, 45 and after this, we get unit step response for the different iterations M which shows peak overshoot, peak time, settling time etc. Then we will compare those responses. After comparision, we will choose best output results.

VI. SWARM INTELLIGENCE

Swarm intelligence systems are typically made up of a population of simple agents interacting locally with one another and also with their environment. Usually there is no centralized control structure dictating how the individual agents should behave, but local interactions between such agents often lead to the emergence of a global behavior [13]. Now we used PSO optimization technique for the best output results.

VII. PARTICLE SWARM OPTIMIZATION

PSO originally was introduced by Kennedy and Eberhart in 1995 [14] and it has been applied to a wide variety of applications and because of it has simplicity, easy implementation, it has been found to continuous in solving of continuous nonlinear optimization problem.

It is a computational algorithm technique which is based on swarm intelligence. This type of method is motivated by the observation of social interaction and animal behaviors such as fish schooling and bird flocking. It mimics the way they find food by the cooperation and competition among the entire population [15]. A swarm consists of individuals, called particles, each of which represents a different possible set of the unknown parameters to be optimized. The swarm is initialized with a population of random solutions [16].

The goal is to efficiently search the solution space by swarming the particles towards the best fitting solution encountered in previous iterations with the intention of encountering better solutions through the course of the process and eventually converging on a single minimum or maximum solution [17]. The performance of each particle is measured according to a pre-defined fitness function, which is related to the problem being solved. The use of PSO has been reported in many of the recent works [18] in this field. PSO has been regarded as a promising optimization algorithm due to its simplicity, low computational cost and good performance.

VIII. PSO ALGORITHM

As described by Eberhart and Kennedy, the PSO algorithm is an adaptive algorithm based on a social-psychological metaphor; a population of individuals (referred to as particles) adapts by returning stochastically toward previously successful regions [19].
It is one of the evolutionary computational optimization which is based on natural system developed in 1995 [14], through simulation of bird flocking in two-dimension space [20] [21].

Particle Swarm has two primary operators: Velocity update and Position update. Each particle is accelerated toward the particles previous best position and the global best position during each generation. A new velocity for each particle is calculated based on its current velocity, the distance from its previous best position, and the distance from the global best position at each iteration. The new velocity is then used to calculate the next position of the particle in the search space. This process is then iterated a set number of times, or until a minimum error is achieved [22].

The detailed operation of particle swarm optimisation is given below [23]:

Step 1: Initialisation: The velocity and position of all particles are randomly set to within pre-defined ranges.
Step 2: Velocity Updating: At each iteration, the velocities of all particles are updated according to

$$\vec{v}_i = w\vec{v}_i + c_1R_1\left(\vec{p}_{i,best} - \vec{p}_i\right) + c_2R_2\left(\vec{g}_{i,best} - \vec{p}_i\right)$$

....(1)

Where $\vec{v}_i$ and $\vec{p}_i$ are the velocity and the position of particle *i*, respectively; $\vec{p}_{i,best}$ and $\vec{g}_{i,best}$ is the position with the best objective value found so far by particle *i* and the entire population respectively; w is a population controlling the flying dynamics; R1 and R2 are random variables in the range [0, 1]; c_1 and c_2 are factors controlling the related weighting of corresponding terms. The inclusion of random variables endows the PSO with the ability of stochastic searching. The weighting factors, c_1 and c_2, compromise the inevitable tradeoff between exploration and exploitation. After updating, $\vec{v}_i$ should be checked and secured within a pre-specified range to avoid violent random walking.

Step 3: Position Updating: Assuming a unit time interval between successive iterations, the positions of all particles are updated according to:

$$\vec{p}_i = \vec{p}_i + \vec{v}_i \qquad .....(2)$$

After updating, $\vec{p}_i$ should be checked and limited to the allowed range.

Step 4: Memory updating. Update $\vec{p}_{i,best}$ and $\vec{g}_{i,best}$ when condition is met.

$$\vec{p}_{i,best} = \vec{p}_i \quad \text{if } f(\vec{p}_i) > f(\vec{p}_{i,best})$$
$$\vec{g}_{i,best} = \vec{g}_i \quad \text{if } f(\vec{g}_i) > f(\vec{g}_{i,best})$$

where *f* $(\vec{x})$ is the objective function subject to maximization.

Step 5: Termination Checking. The algorithm repeats Steps 2 to 4 until certain termination conditions are met, such as a pre-defined number of iterations or a failure to make progress for a certain number of iterations. Once terminated, the algorithm reports the values of $\vec{p}_{i,best}$ and $\vec{g}_{i,best}$ as its solution.

Particles' velocities on each dimension are clamped to a maximum velocity *Vmax.* If the sum of accelerations would cause the velocity on that dimension to exceed *Vmax,* which is a parameter specified by the user, then the velocity on that dimension is limited to *Vmax.*

Vmax is therefore an important parameter. It determines the resolution, or fineness, with which regions between the present position and the target (best so far) position are searched. If *Vmax* is too high, particles might fly past good solutions. If *Vmax* is too small, on the other hand, particles may not explore sufficiently beyond locally good regions. In fact, they could become trapped in local optima, unable to move far enough to reach a better position in the problem space [24].

Each particle adjusts its trajectory towards its best solution (fitness) that is achieved so far. This value is called ***pbest.*** Each particle also modifies its trajectory towards the best previous position attained by any member of its neighborhood. This value is called ***gbest.*** Each particle moves in the search space with an adaptive velocity. Flow Chart of PSO algorithm is shown in the figure 7.

The fitness function evaluates the performance of particles to determine whether the best fitting solution is achieved. During the run, the fitness of the best individual improves over time and typically tends to stagnate towards the end of the run. Ideally, the stagnation of the process coincides with the successful discovery of the global optimum [25].

IX. CONCEPT OF FITNESS FUNCTION FOR THE DESIGN

For our case of design, we had to tune all the three parameters of PID such that it gives the best output results or in other words we have to optimize all the parameters of the PID for best results. Here we define a three dimensional search space in which all the three dimensions represent three different parameters of the PID. Each particular point in the search space represents a particular combination of [K_p K_i K_d] for which a particular response is obtained.

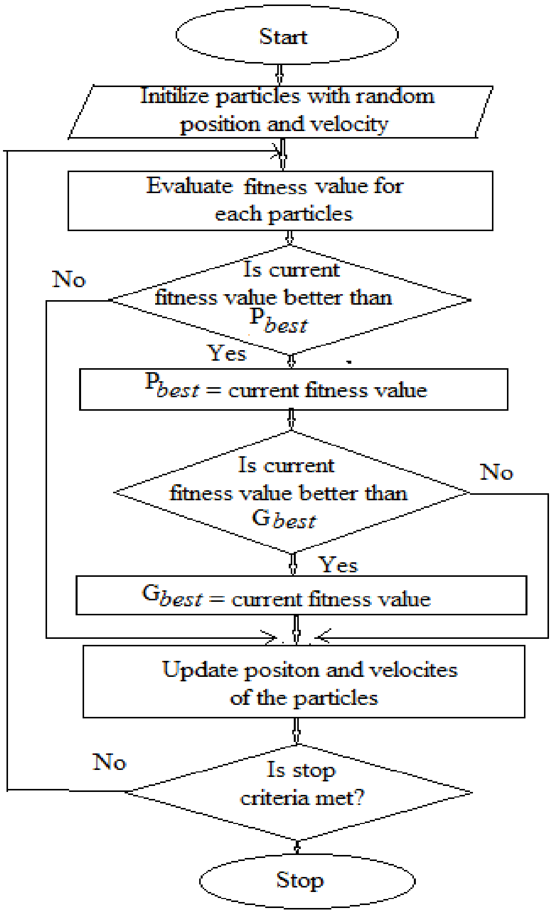

Figure 7: Flow Chart of PSO algorithm

The performance of the point or the combination of PID parameters is determined by a fitness function or the cost function. For the case of our design, we have taken four component functions to define fitness function. The fitness function is a function of steady state error, peak overshoot, rise time and settling time. However the contribution of these component functions towards the original fitness function is determined by a scale factor that depends upon the choice of the designer. For this design the best point is the point where the fitness function has the minimal value. The choosen fitness function is:-

$$F = (1-\exp(-\beta))\,(Mp + ESS) + (\exp(-\beta))(Ts - Tr)$$

Where F:- Fittness function
Mp:- Peak Overshoot
Ts:- Settling Time
Tr:- Rise Time
β:-Scaling Factor(Depends upon the choice of designer)

For our case of design we have taken the scaling factor $\beta = 1$.

In the matlab library we have defined a fitness function. It has the format:-

Function [F] = fitness (K_d K_P K_i)

which has PID parameters as input values and it returns the fitness value of the PID based controlled model as its output [26].

X. PID CONTROLLER TUNING USING PSO

Figure 8 shows the structure of PID controller optimization process.

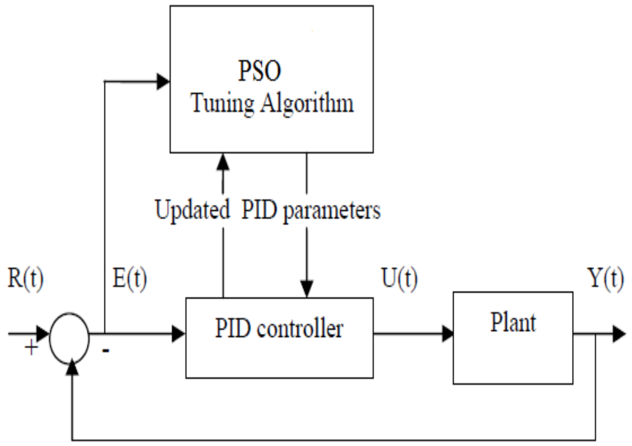

Figure 8: Block diagram of PID controller tuning

We can apply PSO to tune value of three parameters repeatedly until they achieve an acceptance level of performance [11].

XI. PSO BASED SIMULATION AND RESULTS

In our simulations using PSO algorithm, we have varied the number of iterations. We present a comparative study of the performance of the initial global best position out of randomly initialized swarm particles to the performance of the final global best position which comes after the application of "particle swarm optimization" algorithm.

XII. SIMULATION RESULTS WITH DIFFERENT NUMBER OF ITERATIONS

Unit step response of feedback control scheme for different no. of iterations are shown in the figure 9.

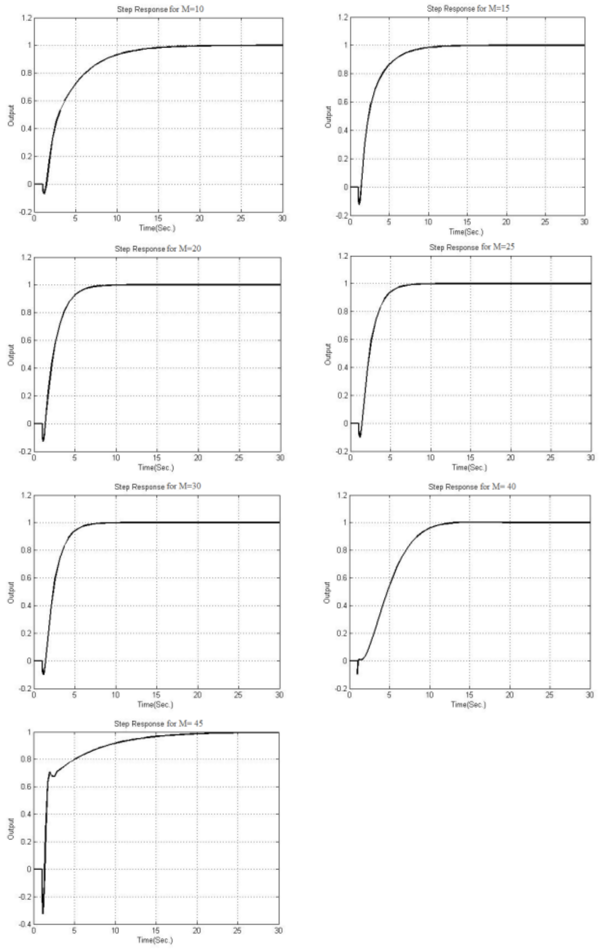

Figure 9: Step responses of PID controller for different no. Of the iterations such as M=10, 15, 20, 25, 30, 40, 45.

In figure 9, Each unit response of different iteration shows peak overshoot, settling time, peak time etc. If we compare these responses, we get the best output result. Which is shown in figure 10 and table 6.

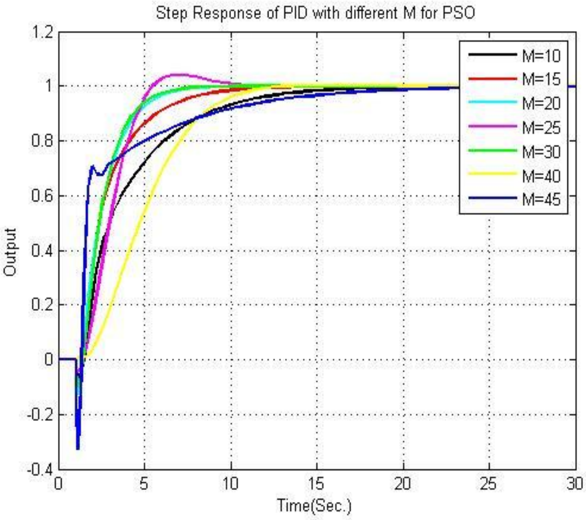

Figure 10: comparison of step response of PID controller with different no. of the iterations M for PSO.

XIII. RESULTS AND DISCUSSION

This section evaluates the controller perfromance on the basis of tranisent response and error criteria. Table 3 shows the comparative tranisent response of conventional PID controller.

Table 3: Transient response of controllers

Parameters/ Type	Peak overshoot (%)	Rise time (Sec)	Delay time (Sec)	Sett time (Sec)	Peak time (Sec)
PID	8.1351	3.979	2.9459	8.4172	6.704
PID with disturbances	21.3435	3.865	2.756	14.075	5.176
PID with disturbances and delay	15.1946	3.979	2.782	13.498	5.482

Table 4 shows the error criteria for different controllers. From transient response analysis in table 3 and error analysis in table 4 it is evident that the hybrid fuzzy controller is best for concentration control.

Table 4: Performance criteria of controllers.

Parameters/ Type	IAE	ISE	ITAE
PID	2.178	1.379	5.226
PID with disturbance	2.32	1.552	7.21
PID with Disturbance with delay	2.423	1.721	8.074

Gain values and Fitness function for the different iteration of PSO are shown in table 5.

Table 5: Gain values and Fitness function for the different iteration of PSO.

M (No. Of Iteration)	K_p	K_i	K_d	f_{best}	Elapsed Time t (sec.)
10	.6451	.5179	.0368	.1967	53.614
15	.9964	.7949	.2895	.1902	103.45
20	.9402	.9356	.3960	.1836	269.12
25	.3065	.8568	.2970	.1621	157.97
30	.8033	.9580	.2073	.1589	175.74
40	.0035	.4130	.4628	.1324	249.52
45	2.2519	.6329	.3927	.0984	1106.3

Table 6 shows the the comparative transient response such as peak overshoot, rise time, delay time, settling time and peak time, of PID controller for the different iteration of PSO.

Table 6: Transient response for different iteration of PSO

M (No. Of Iteration)	Peak overshoot	Rise time	Delay time	Settling time	Peak time
10	-6.7717	15.023	2.936	10	10
15	-1.6014	10.319	2.682	7.275	10
20	-0.1857	7.393	2.581	5.466	10
25	4.3362	6.249	2.311	3.427	5.535
30	-0.1117	7.212	2.312	5.203	10
40	-4.0377	12.193	4.810	9.624	10
45	-8.2679	21.901	1.892	10	10

Table 7 shows the performance criteria of the different iteration of PSO.

Table 7: Performance criteria for different iteration of PSO

M (No. Of Iteration)	Integral Absolute Error (IAE)	Integral Square Error (ISE)	Integral Time Absolute Error (ITAE)
10	3.301	1.739	14.2
15	2.151	1.234	6.502
20	1.828	1.178	4.368
25	1.327	1.1385	3.521
30	1.785	1.201	4.086
40	4.171	2.866	15.75
45	2.689	1.085	15.26

When we see the table 6, we can say that step response for iteration M=25 of PSO have the best output results.

XIV. CONCLUSION

This paper presents Designing & Optimization of the Controller Parameters for CSTR (Continuous Stirred Tank Reactor) system using Particle Swarm Optimization. The aim of the proposed controller is to regulate the product concentration of isothermal CSTR. After time response analysis it is observed that PID controller using PSO provides a satisfactory control performance.

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