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Firefly Algorithm Based SISO PID Controller

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ABSTRACT: For the application of turning PID controllers for time delayed model with a specific stability analysis on the unstable phase of a Bio- reactor system, this paper proposes a detailed analysis of fire fly algorithm based PID controller. To find the best value of K_p, K_i and $K_d$and to compare the output of firefly algorithm with other types of algorithm like PSO. After the analysis of PID controller response Kp,Ki,Kd values are fixed and find out which method is suitable for finding appropriate values for PID controller and Simulation results are displayed in this paper.

KEYWORDS*:* Firefly algorithm,PSO-Based PID Controller,BFO Algorithm, bio-reactor

I.INTRODUCTION

Despite important developments in advanced method management schemes like Model prognosticative management (MPC), Internal Model management (IMC), and slippery Mode management (SMC), PID controllers area unit still wide employed in industrial system wherever reference pursuit and disturbance rejection area unit a serious task. Proportional + Integral + spinoff (PID) controllers area unit wide utilized in industrial applications to produce optimum and strong performance for stable, unstable and non-linear processes. It may be simply implementable in analog or digital type. Further, it supports standardization and on-line retuning supported the performance demand of the method to be controlled. Open-loop unstable systems area unit principally discovered in chemical process industries and for economical and/or safety reasons, the activity loops to be operated in unstable steady state . For unstable systems, there exist a minimum and most values of controller gain, and the average of this limiting price is taken into account to style the controller to stabilize the system. the rise in time delay within the method narrows down the limiting price and it restricts the performance of the control system below control. additionally, these systems show uncommon overshoot or inverse response as a result of the presence of negative or positive zeros . The literature offers details regarding varied theoretical studies on fine standardisation of PID controllers for open loop unstable system . Most of the controller standardization approaches planned for unstable system might need an approximate initial or second order transfer perform model with delay. Further, for real time application, the model might not be promptly accessible in apply or is also ever-changing as a result of uncertainty . The model-based controller standardisation needs complex computations to spot the controller parameters. To overcome this, it's necessary to use soft computing based mostly model freelance controller auto-tuning strategies.

II. BIOCHEMICAL REACTOR

The organic chemistry reactor is a necessary unit operation during a wide variety of biotechnological processes. organic chemistry reactors ar accustomed manufacture an outsized variety of intermediate and final product, as well as medical product, food, beverages, and industrial solvents [2, 3]. For organic chemistry reactors, unstructured odels ar primarily used for its simplicity. the subsequent unstructured models will describe a variety of bioreactors and schematic of a organic chemistry reactor is as shown in Fig.1.

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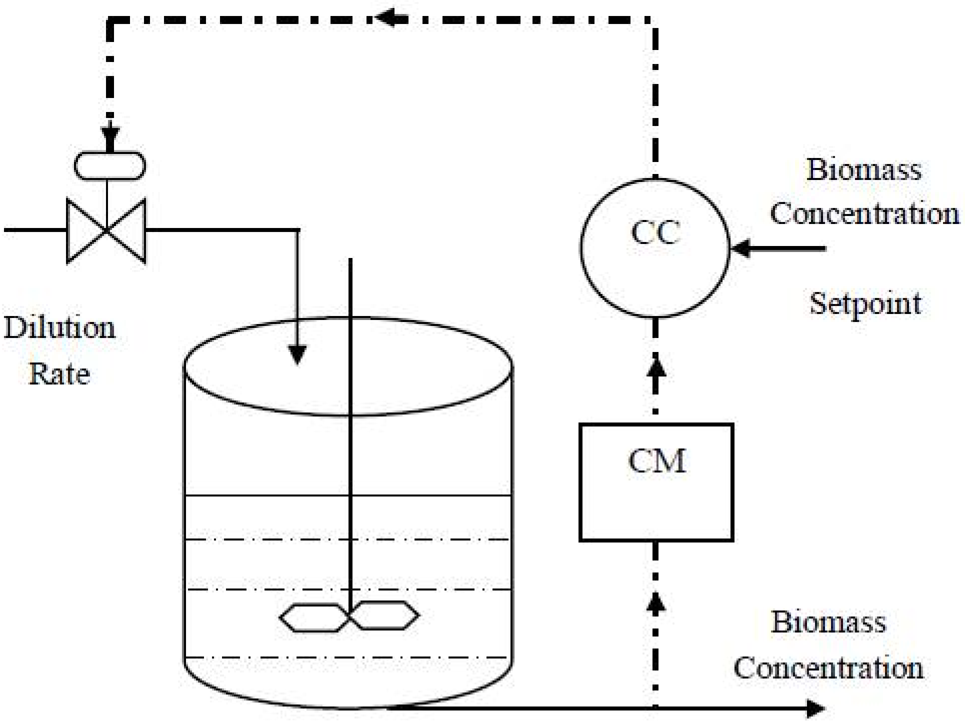

Fig. 1 Biochemical Reactor

III. CONTROLLER DESIGN

1. PID Controller

The flexibility and strength of the inflammatory disease controller makes it wide applied in several applications. The continuous management law of inflammatory isease controller is

$$u(t) = K_p e(t) + K_i \int_0^t e(t)\, d(t) + K_d \frac{d}{d_t} e(t)$$

Where e(t) is that the error signal between the setpoint and actual output, u(t) is that the controller output and Kp, Ki, Kd are the pelvic inflammatory disease controller gains. A basic pelvic inflammatory disease controller directly operates on the error signal and this could manufacture an outsized overshoot within the method response as a result of the proportional and spinoff kick The process is unstable and to beat the result of proportional and by-product kick, a modified inflammatory disease structure referred to as I-PD is taken into account . In I-PD structure, the integral term responds supported the error and also the P+D terms works supported the measured process output

2. Firefly Algorithm

2.1 Behaviour of Fireflies

The flashing light-weight of fireflies is an incredible sight within the summer sky within the tropical and temperate regions. There square measure regarding 2 thousand firefly species, and most fireflies turn out short and syncopated flashes. The pattern of flashes is ften distinctive for a specific species. The flashing light-weight is created by a method

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of luminescence, and also he true functions of such sign systems square measure still debating. However, 2 basic functions of such flashes square measure to draw in mating partners (communication), and to draw in potential prey. additionally, flashing may additionally function a protecting warning mechanism. The syncopated flash, the rate of flashing and also the quantity of your time kind a part of the signal system that brings each sexes along. Females reply to a male's distinctive pattern of flashing within the same species, whereas in some species like photuris, female fireflies will mimic the union flashing pattern of alternative species therefore on lure and eat the male fireflies World Health Organization could mistake the flashes as a possible appropriate mate. The flashing light-weight are often developed in such the simplest way that it's related to the objective operate to be optimized, that makes it potential to formulate new optimization algorithms. within the remainder of this paper, we'll initial define the fundamental formulation of the Firefly formula (FA) so discuss the implementation as well as analysis thoroughly.

2.2 Firefly Algorithm

Now we will idealize a number of the flashing characteristics of fireflies thus on develop firefly-inspired algorithms. For simplicity in describing our Firefly Algorithm (FA), we tend to currently use the subsequent 3 idealised rules: 1) all fireflies are androgynous so one firefly are going to be drawn to different fireflies despite their sex; 2) Attractiveness is proportional to their brightness, so for any 2 flashing fireflies, the less brighter one can move towards the brighter one. The attractiveness is proportional to the brightness and that they each decrease as their distance will increase. If there's no brighter one than a specific firefly, it will move randomly; 3) The brightness of a firefly is affected or determined by the landscape of the target operate. For a maximization downside, the brightness will merely be proportional to the worth of the target operate. Other forms of brightness may be outlined in a very similar thanks to the fitness operate in genetic formulas or the microorganism hunt algorithm (BFA).

In the firefly formula, there ar 2 vital issues: the variation of sunshine intensity and formulation of the attractiveness. For simplicity, we will invariably assume that the attractiveness of a firefly is set by its brightness that in turn is related to the encoded objective operate. In the simplest case for optimum improvement issues, the brightness I of a firefly at a selected location x is chosen as I(x) / f(x). However, the attractiveness is relative, it ought to be seen within the eyes of the person or judged by the opposite fireflies. Thus, it'll vary with the space rij between firefly i and firefly j. additionally, intensity level decreases with the space from its supply, and light-weight is additionally absorbed within the media, therefore we should always enable the attractiveness to vary with the degree of absorption. within the simplest kind, the light intensity I(r) varies consistent with the inverse sq. law I(r) = Is r2 where Is is that the intensity at the supply. For a given medium with a hard and fast lightweight absorption coefficient , the sunshine intensity I varies with the space r. That is

$$I = I_0 e^{-r}$$

where I0 is the original light intensity.
As a firefly's attractiveness is proportional to the sunshine intensity seen by adjacent fireflies, we are able to currently outline the attractiveness of a firefly by

$$\beta = \beta_0 e^{-r2}$$

where β_0 is the attractiveness at r = 0.

3. PSO-Based PID Controller Design

The Particle Swarm Optimization formula makes an attempt to mimic the process of cluster communication of individual information, to achieve some optimum property. The swarm is initialized with a population of random solutions. every particle within the swarm may be a completely different doable set of the unknown parameters to be optimized. Representing a degree within the answer house, every particle adjusts its flying toward a possible space consistent with its own flying expertise and shares social info among particles. The goal is to with efficiency search the answer house by swarming the particles toward the simplest fitting answer encountered in previous iterations with the intent of encountering higher solutions through the course of the process and eventually convergence on one minimum error. At the start, every particle of the population is scattered willy-nilly throughout the whole search house. Under the steerage of the performance criterion, particles in their flies dynamically alter their velocities consistent with their own flying expertise and their companions flying experience. every particle remembers its best position obtained to this point, that is denoted pbest. It additionally receives the globally best position achieved by any particle within the population, that is denoted as

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gbest . The updated velocity of every particle are often calculated victimisation the current velocity and therefore the distances from pbest and gbest.

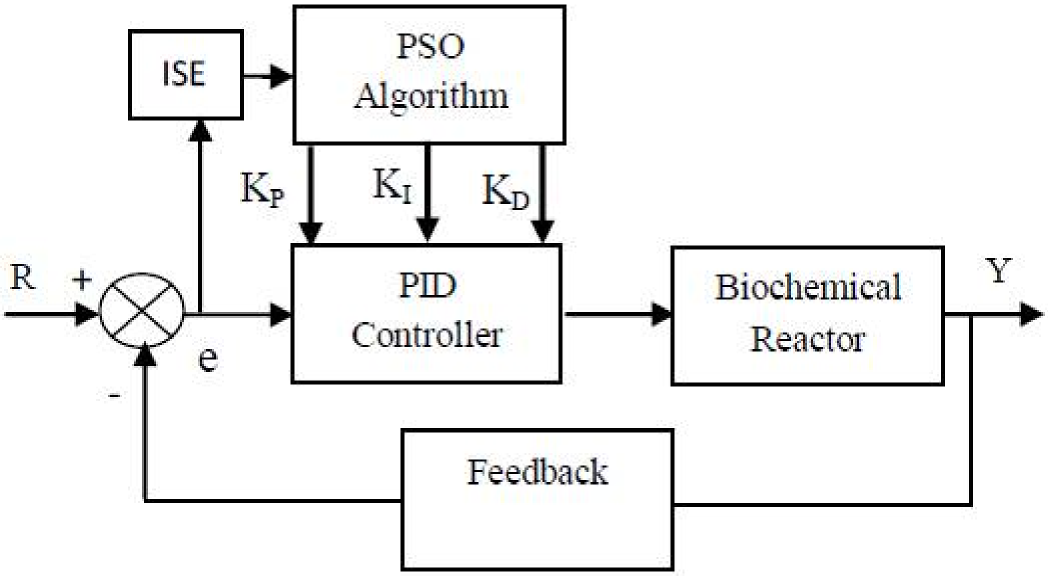

Fig. 2 PSO based PID controller

The mathematical expression for Velocity update

$$V_i^{(k+1)} = W_i V_i^k + C_1 \; xR_1 x \; (pbest - S_i^k) + C_2 \; xR_2 x \; (gbest - S_i^k)$$

Vi^k -	current velocity of particle i at iteration k,
$Vi^{(k+1)}$ -	updated velocity of particle i,
Wi -	different inertia weight of particle i ,
C1, C2 -	positive constants,
Si^k -	current position of particle i at inertia k,
R1, R2 -	random number between 0 and 1.

The new position will be changed mistreatment this position and updated swarm position is

$$S_i^{(k+1)} = S_i^{k} + V_i^{(k+1)}$$

The parameter Badger State is inertia weight that will increase the performance of PSO. The larger price of Badger State will favour higher ability for world search and lower price of Badger State implies the next ability for native search. to realize a higher performance, the linearly reduced price of inertia is

$$W = W\,max - Iter\,x\,[(W\,max - W\,min) / (Iter\,max)]$$

Where $Iter_{max}$ is the maximum of iteration in evolution process, W_{max} is maximum value of inertia weight , W_{min} is the minimum value of inertia weight, and *Iter*is current value of iteration.

4. Bacterial Foraging Optimization algorithm

The microorganism hunt optimisation (BFO) planned by Passino within the year 2002 is predicated on natural process that tends to eliminate animals with poor hunt ways. Over bound real-world optimisation issues, BFO has been according to vanquish several powerful optimisation algorithms in terms of convergence speed and final accuracy.

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The BFO algorithmic program that mimics the on top of four mechanisms is gift Chemo taxis: Represents the step size of the bacterium

Swarming: Grouping of the microorganism that permits them to maneuver in a very concentric pattern.

Reproduction: Maintains the population in the swarm.

Elimination and Dispersal: The BFO formula makes some microorganism to urge eliminated and distributed with chance to confirm that the microorganism don't get at bay into a neighborhood optimum rather than the world optima.

IV. SIMULATIONS AND RESULTS

1. fire fly algorithm

The stationary part of the bioreactor that has Associate in Nursing operation within the stable region, the simulations of the model that is devised within the MATLAB Simulink are coupled with the algorithmic rule and a nonstop iterations ar loped. the subsequent simulation results ar obtained for the hearth Fly algorithmic rule for the stationary part.

For the stationary section, the transfer operate of the bio-reactor as delineate higher than, a MATLAB based mostly simulation model is developed and every one the higher than mentioned algorithmic rules were enforced to unravel the improvement downside of that the hearth Fly (FF) algorithm established to be higher when put next with the opposite. attributable to house constraints we've got depicted the results of FF that is employed to get optimum values of Kp, Ki and Kd.

The simulation result of the fire fly algorithm is shown[4] and the output of the simulation are given as following fig.3 and Fig.4 .

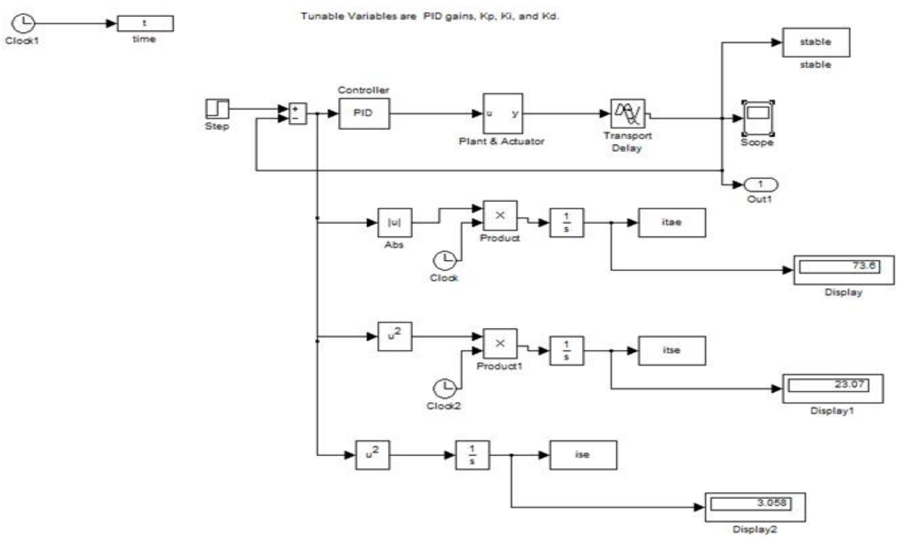

Fig. 3 simulation for firefly algorithm

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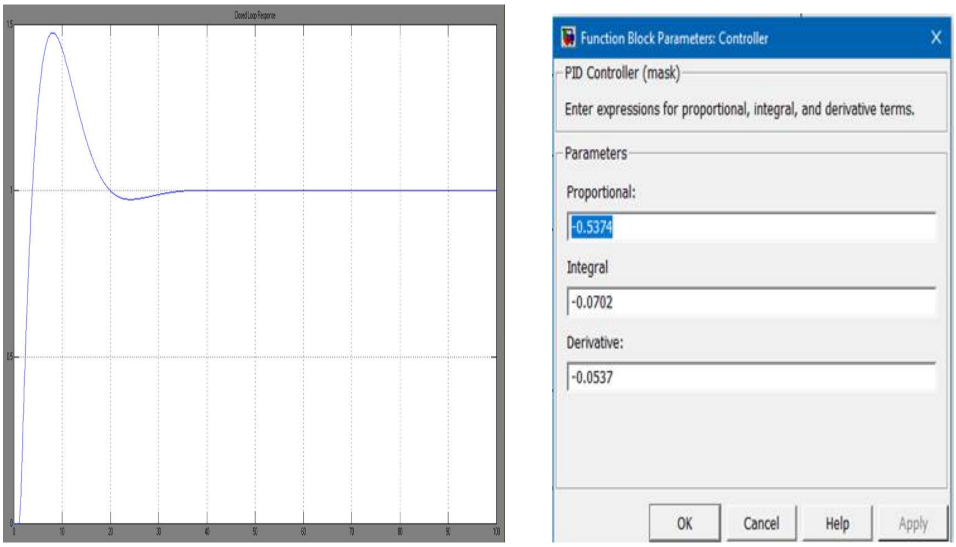

Fig.4 output for firefly algorithm

2. PSO based algorithm

The stationary part of the bioreactor that has associate degree operation within the stable region, the simulations of the model that is devised within the MATLAB Simulink area unit joined with the formula and an eternal iterations area unit coiled. the subsequent simulation results area unit obtained for the PSO formula for the expansion part of the second order time delayed system. For the expansion part, the transfer operate of the bio-reactor as delineated on top of, a MATLAB based mostly simulation model is developed and every one the on top of mentioned formulas were enforced to unravel the optimisation drawback of that the PSO algorithm proved to be higher in comparison with the opposite. attributable to area constraints we've delineate the results of PSO solely that is employed to getoptimum values of Kp, Ki and Kd. in comparison with the opposite thought of algorithms.[1]

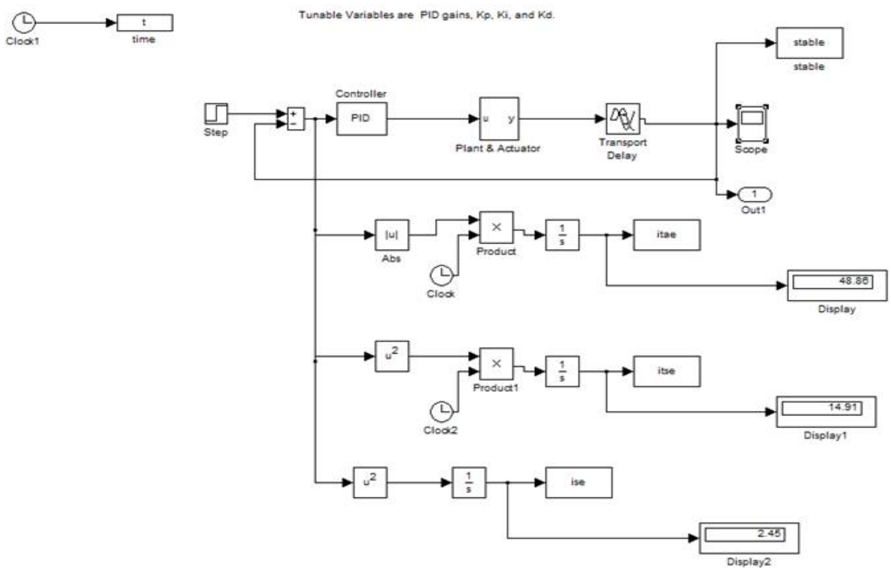

Fig. 5 Simulation for PSO algorithm

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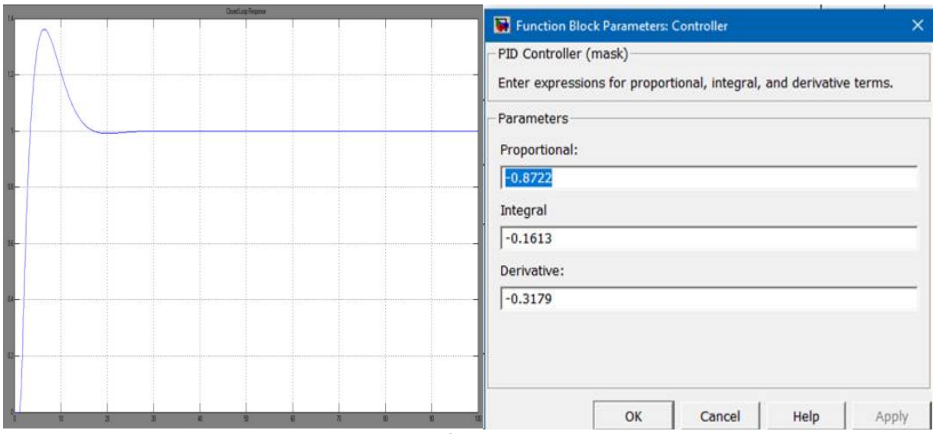

Fig. 6 Output for PSO algorithm

Based on the value in the reference [3] the simullation has been designed as shown in the Fig.7 and Fig.8 as follows

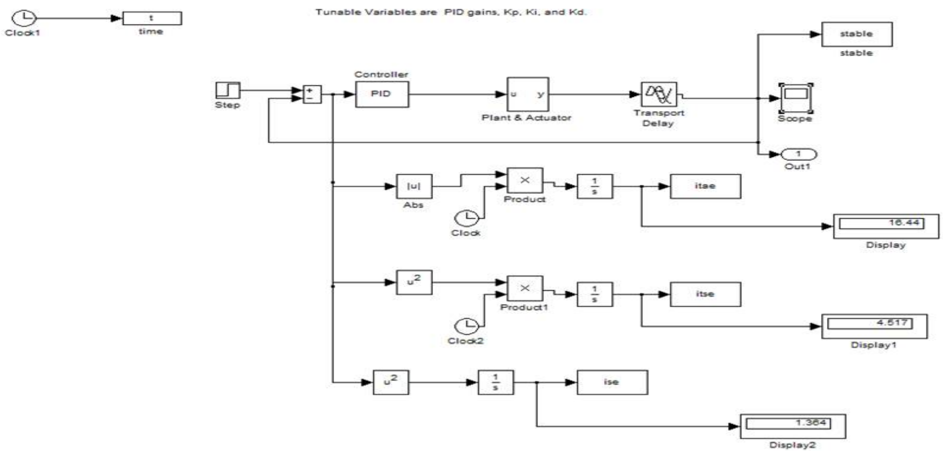

Fig.7 Simulation for PSO

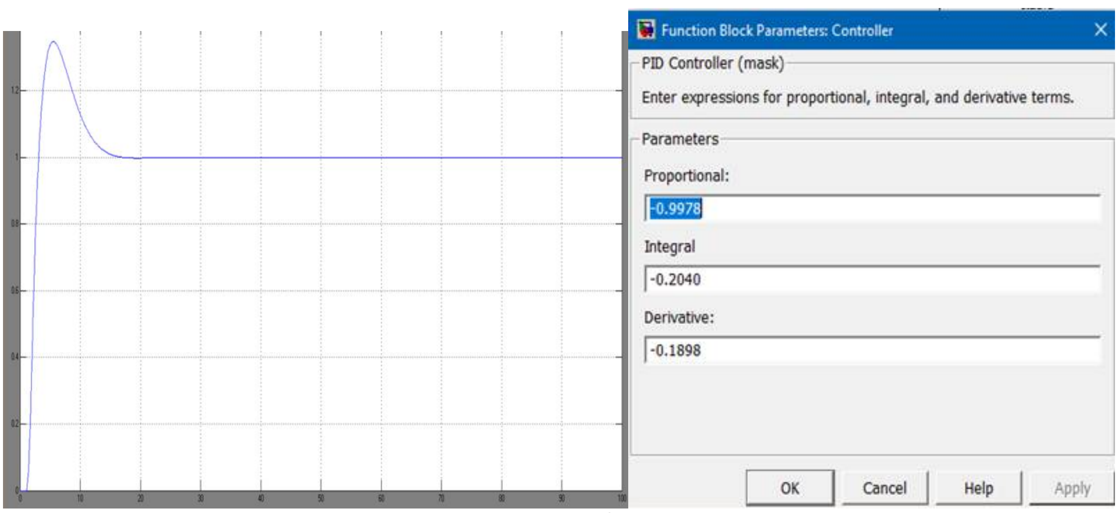

Fig.8 output of PSO

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V. CONCLUSION

Thus the kp, ki & kd values are determined by using firefly algorithm for a bio-reactor have been determined. The values obtained from firefly algorithm is compared with the other methods of algorithm. Placing appropriate values for PID controller will improve the response of system. These results are obtained from simulation and results are shown in above section. It will be simulated using MATLAB Software.

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