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Comparison between Speed Control Dc Motor Using Genetic Algorithm and Pso-PidAlgorithm

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Abstract

DC motor speed control in this paper genetic algorithm fed with PID controller and particle swarm optimization technique has been compared. The application of particle swarm optimization for adjusting the gains of proportional-integral-derivative (PID) controller parameters of a DC motor is presented and genetic algorithm based controller are tuned with PID give the betterresult. Here, the model of a DC motor speed control is considered as a second order system. Genetic Algorithm is soft computing techniques which are used for optimization for obtaining the best possible result. The Genetic Algorithm functions on three basic genetic operators of selection, crossover, mutation. This paper details how efficiently DC motor parameters for the optimal result using both the optimization. The proposed approach improved features including easy implementation and good computational efficiency. PID controller tuning parameters for optimal yields of high-quality solutions faster.

Key words: DC motor, PID controller, Genetic Algorithm, Particle Swarm Optimization, mutation, Genetic operators.

1. Introduction

The DC motors are in general much more adaptable speed drives than AC motors which are associated with a constant speed rotating field. It is observed that most of the industry is operating under stress condition further load parameter and control variable exhibit uncertainness in real practice and in fact these are random variables. Calculated values of load variable normally contain various inaccuracies. It has been observed that error may vary in the range of 5-10%. A few percentage errors may be required tolerable in the area of the load speed controlling where these inaccuracies in the entire controller. In such situation minor inaccuracy in speed control are of little concern. Further the speed controller can always be designed to have sufficiently low effect on the non-linearity of DC motor; so as to worst effect of parameter uncertainty can be accounted. In real time operation, the situation is different; design controller may encounter situation never imagined by designer before it took its present shape. Hence, in real time operation condition, risk of affecting nonlinearity of motor is always present. Here it is designed a controller which not affects the nonlinearity in DC motor.

DC motors have long been the primary means of electrical traction. Direct current (DC) motors have been widely used in many industrial applications such as electric vehicles, electric cranes and steel rolling mills due to precise, wide, simple and continuous control characteristics. The development of high performance motor drives is very important in industrial as well as in other application. The advantage of using controller is its simplicity to implement. It is not easy to find another controller with such a simple structure to be comparable in performance. A very important step in the use of controllers is the controller parameters and tuning process. Fuzzy rule-based models are easy to comprehend because it uses linguistic terms and the structure of if-then rules. In this paper, an optimal PID controller solution is defined for DC motor drive systems using Particle Swarm Optimization Technique (PSO) and by Genetic Algorithm. There is no constraint in the searching space of the optimal PID parameters. The PID tuning algorithm is applied to the speed control of DC motors.

2. DC MOTOR

The stator of the DC motor has poles, which are excited by DC current to produce Magnetic fields. The rotor has a ring-shaped laminated iron-core with slots. Coils with several turns are placed in the slots. The distance between the two legs of the coil is about 180 electric degrees. DC motors are characterized by their versatility. By means of various combinations of shunt, series and separately excited field winding they can be designed to display a wide variety of volt ampere or speed torque characteristics for both dynamic and steady state operation. The separately excited dc motor model is chosen for its good electrical and mechanical performances rather than other DC motor models. The DC motor is driven by applied voltage. In DC motor, the torque may be controlled by varying the armature current or field current. One of these is varied to control the torque while the other is held constant.

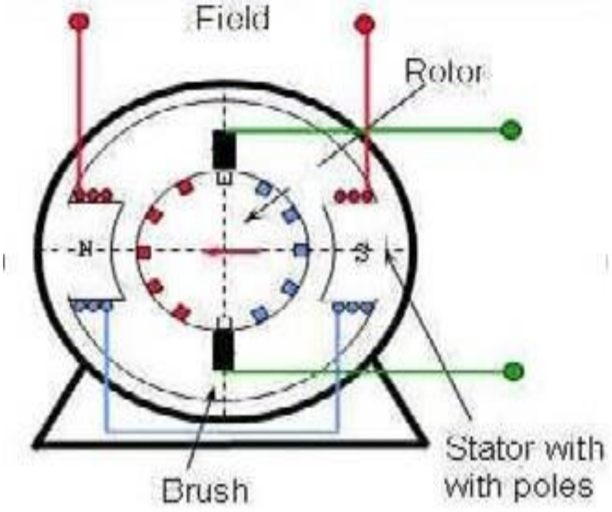

Figure 1 Basic diagram of DC motor

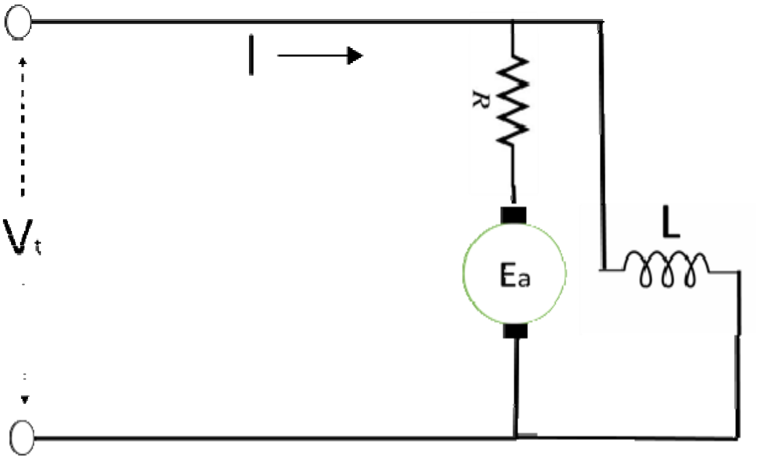

Figure 2 Circuit diagram of DC motor

According to KVL,

$V_t = Eb + I_a R_a$ (1)

$V_t = L\frac{di}{dt}$ (2)

$Tm = Kt * \mathrm{i}$ (3)

$Tm = J\frac{d^2\theta}{dt} + \mathrm{B}\frac{d\theta}{dt}$ (4)

$$Ea = Kb\,\frac{d\theta}{dt}$$

R: Armature resistance in ohm
L: Armature inductance in henry
i: Armature current in ampere
V: Armature voltage in volts
eb: Back emf voltage in volts
Kb: Back emf constant in volt/ (rad/sec)
KT: Torque constant in N.m/Ampere
Tm: Torque developed by the motor in N.m
θ (t): Angular displacement of shaft in radians
J: Moment of inertia of motor and load in Kg.m2/rad
B: Frictional constant of motor and load in N.m/ (rad/sec)

3. PID CONTROLLER

PID controllers are composed of three basic control modes i.e. proportional mode integral mode and derivative mode. They are simple to implement and provide good performance. A PID controller does not "know" the correct output to bring the system to the set point. It moves the output in the direction which should move the process toward the set point and needs to have feedback to perform. PID tuning is a complex problem, even though there are only three parameters and in principle is easy to evaluate, because it must satisfy complex criteria within the limitations of PID control. PI control with its two term functionality covering treatment to both transient and steady state response, offers the simplest and yet most efficient solution to many real world control problems. In spite of the simple structure and robustness of this controller, optimally tuning gains of PI controllers have been quite difficult. When the control problem is to regulate the process output around a set point, it is natural to consider error as an input, and it follows that the integral of the error.

The PID controller has the following form in the time domain

$$\mu(t) = k_p e(t) + k_i \int_0^t e(t)\,dt + k_d \frac{de(t)}{dt} \qquad (1)$$

Proportional Control	$\mu(t) = k_p\, e(t)$
Integral Control	$\mu(t) = k_i \int_0^t e(t)\,dt$
Derivative Control	$\mu(t) = k_d \frac{de(t)}{dt}$

4. PARTICLE SWARM OPTIMIZATION (PSO) ALGORITHM

Since the introduction of the particle swarm optimizer by James Kennedy and Russ Eberhart in 1995, numerous variations of the basic algorithm have been developed in the literature. Each researcher seems to have a favorite implementation - different population sizes, different neighborhood sizes, and so forth. In this paper we examine a variety of these choices with the goal of defining a canonical particle swarm optimizer, that is, an off-the shelf algorithm to be used as a good starting point for applying PSO. The original PSO formulae defined each particle as a potential solution to a problem in D-dimensional space.

With particle i represented Xi=(xi1,xi2,...,xiD). Each particle also maintains a memory of its previous best position, Pi=(pi1,pi2,...,piD), and a velocity along each dimension, represented as Vi=(vi1,vi2,...,viD).At each iteration the P vector of the particle with the best fitness in the local neighborhood, designated g, and the P vector of the current particle are combined to adjust the velocity along each dimension, and that velocity is then used to compute a new position for the particle. The portion of the adjustment to the velocity influenced by the individual's previous best position (P) is considered the cognition component, and the portion influenced by the best in the neighborhood is the social component.

In Kennedy's early versions of the algorithm, these formulae are:

vid=vid+j1*rand()*(pid-xid)+j2*rand()*(pgd-xid) (2)

xid=xid+vi (3)

Constants j1 and j2 determine the relative influence of the social and cognition components, and are often both set to the same value to give each component (the cognition and social learning rates) equal weight.

Angeline, in [1], calls this the learning rate. A constant, Vmax, was used to arbitrarily limit the velocities of the particles and improve the resolution of the search.

In [9] Eberhart and Shi show that PSO searches wide areas effectively, but tends to lack local search precision.

Their solution in that paper was to introduce w, an inertia factor that dynamically adjusted the velocity over time, gradually focusing the PSO into a local search:

vid=w*vid+j1*rand()*(pid-xid)+j2*rand()*(pgd-xid) (4)

More recently, Maurice Clerc has introduced a constriction factor K that improves PSO's ability to Constrain and control velocities. In, Shi and Eberhart found that K, combined with constraints on Vmax Significantly improved the PSO performance. K is computed as:

K = 2

| 2 - j - j 2 - 4j |

Where j=j1+j2,j>4, and the PSO is then:

vid = K(vid+j1*rand()*(pid - xid)+j2*rand()*(pgd - xid))

To test the various parameter settings, we start with the PSO settings Shi and Eberhart used in: particles, j1 and j2 both set to 2.05, Vmax set equal to Xmax, and incorporating Clerc's constriction factor. We assume, in absence of evidence otherwise, that the neighborhood is global, and particles are updated synchronously (That is, g best is determined between iterations).

At first we control the DC motor by PID controller

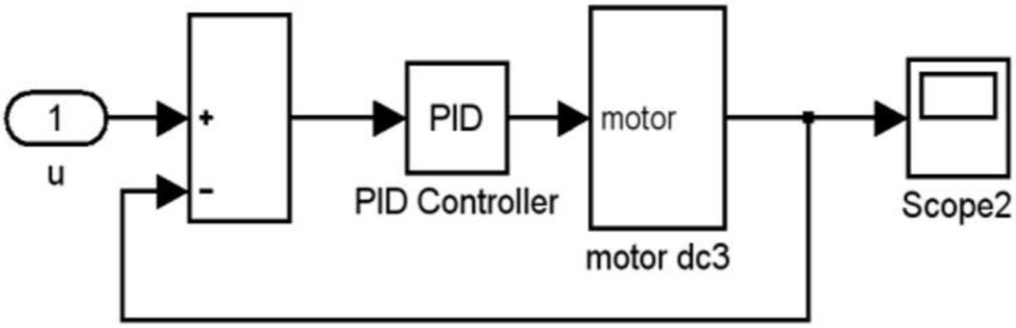

Figure 3 The block diagram of a PID controller dc motor

5. IMPLEMENTATION OF PSO-PID CONTROLLER

In this paper, a PID controller using the PSO algorithm is developed to improve the results of speed control of DC motor. The PSO algorithm is mainly utilized to determine three optimal controller parameters kp, ki, and kd, such that the controlled system could obtain a desired step response output

Result of PSO-PID Controller

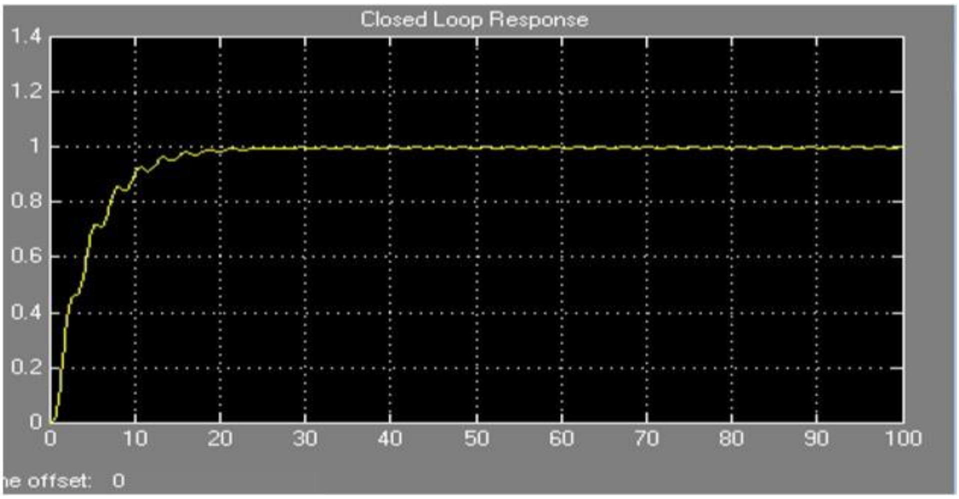

Figure 4 Simulated results PID controller of DC motor

6. GENETIC ALGORITHM

GA is a stochastic global adaptive search optimization technique based on the mechanisms of natural selection. Recently, GA has been recognized as an effective and efficient technique to solve optimization problems. GA was first suggested by John Holland and his colleagues in 1975. GA starts with an initial population containing a number of chromosomes where each one represents a solution of the problem, the performance of which is evaluated by a fitness function.

GA has been recognized as an effective and efficient technique to solve optimization problems. Compared with other optimization techniques, such as simulating annealing and random search method techniques, GA is superior in avoiding local minima, which is a significant issue in the case of nonlinear systems [7]

7. GENETIC OPERATORS

In each generation, the genetic operators are applied to selected individuals from the current population in order to create a new population. Generally, the three main genetic operators of reproduction, crossover and mutation are employed. By using different probabilities for applying these operators, the speed of convergence can be controlled. Crossover and mutation operators must be carefully designed, since their choice greatly contributes to the performance of the whole genetic algorithm [8]

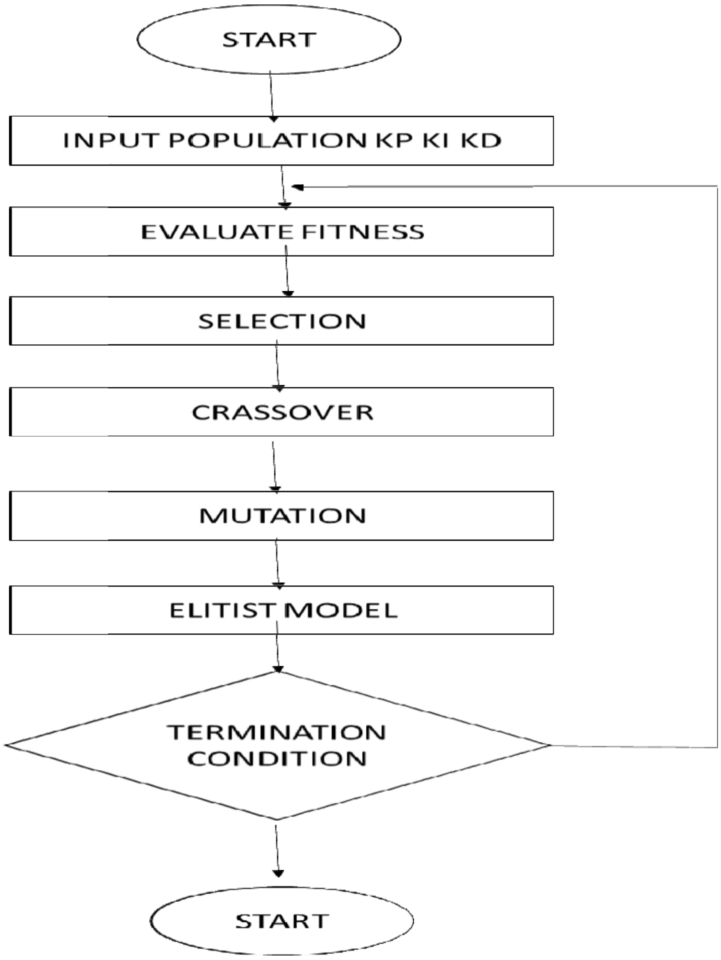

Figure 4 Flowchart of Genetic Algorithm

GA has many variants like Real coded GA, Binary coded GA, Saw tooth GA, Micro GA, Improved GA, Differential Evolution GA. This paper is based on Binary coded G.A. The binary coded genetic algorithm is a probabilistic search algorithm that iteratively transforms a set (called a population) of mathematical objects (typically fixed-length binary character strings), each with an associated fitness value, into a new population of offspring objects using the Darwinian principle of natural selection and using operations that are patterned after naturally occurring genetic operations, such as crossover and mutation. [9]

In the proposed work a DC Motor model is called by a program which is coded in Matlab for a fitness function i.e cost function. In order to use GA to tune the PID controller for DC motor. Variables Kp, Ki, & Kd are coded to solve string structures. Binary coded string having 1‟s & 0‟s are mostly used.

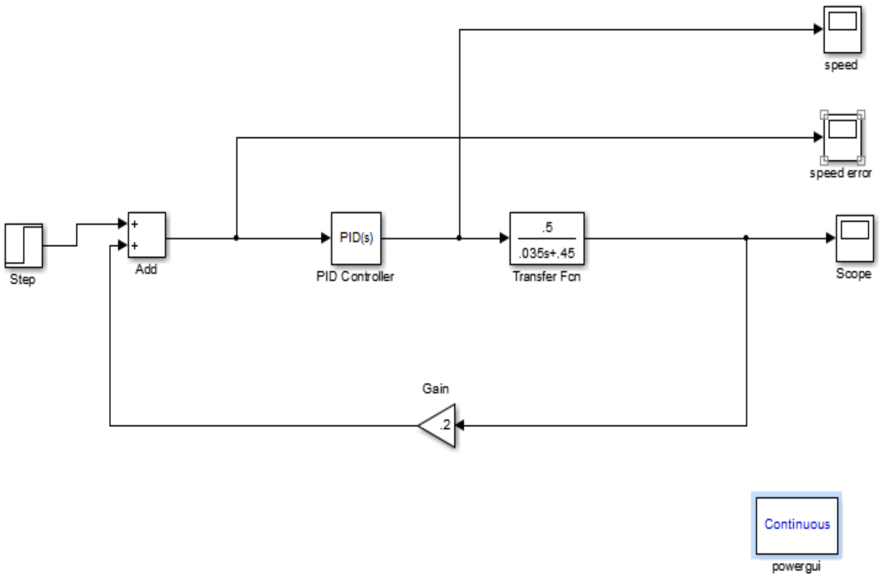

Figure 5 GA based PID controller simulation model

The length of string is usually determined according to the desired solution accuracy. Here 10 bits are used to code each variable. We can use 8 bit & 4 bit also. Thereafter select the random strings from the population to form the mating pool.

In order to use roulette-wheel selection procedure, we calculate the average fitness of the population. Then the mating pool strings are used in the crossover operation. The next step is to perform mutation on strings in the intermediate population.

8. RESULT

It is clear from both results that the simple PID controller is not getting the accurate results but the G.A based PID controller getting the proper optimized gain values of KP, Ki and Kd. Below fig. shows the comparison of both the result.

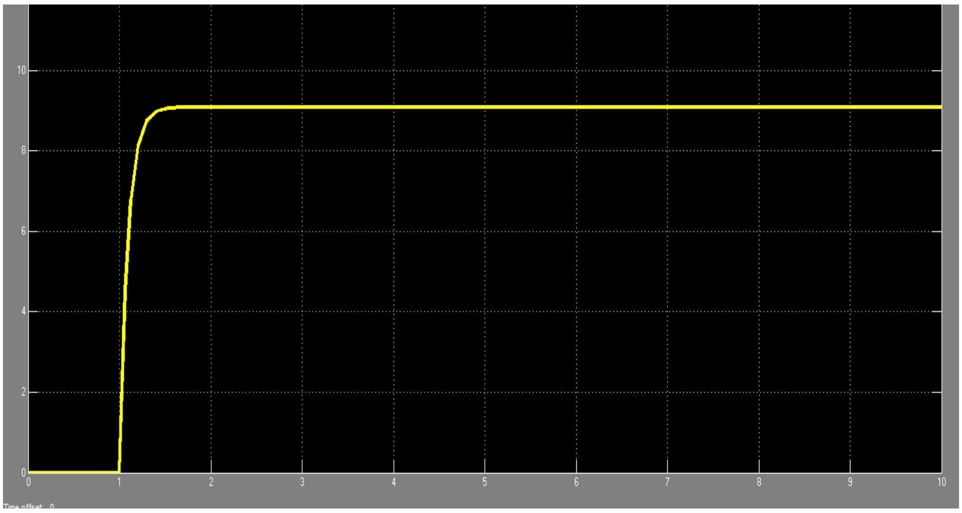

Figure 6 Result of GA based PID controller

PID controller and genetic algorithm with PID

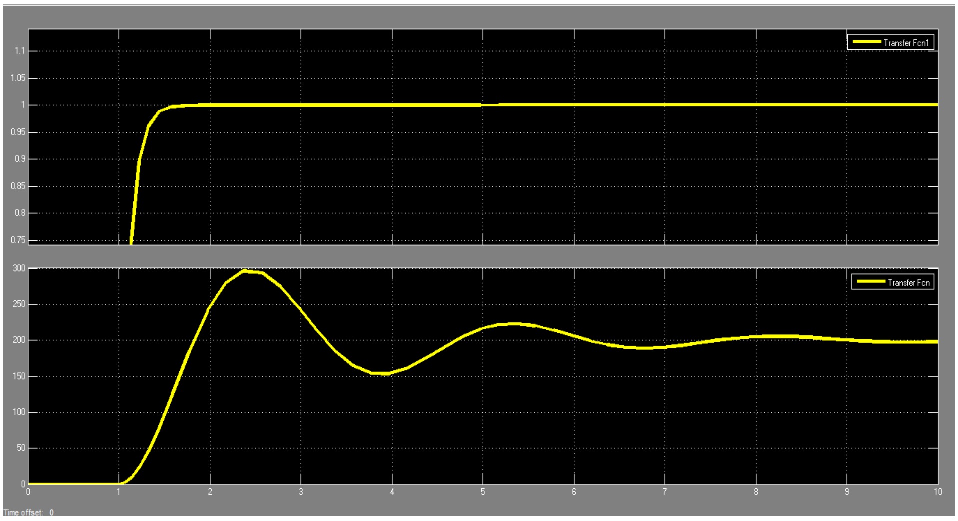

Figure 7 Result GA based PID controller and only PID controller

9. CONCLUSIONS

This paper shows two different methods of determining the PID controller parameters using PSO algorithm and Fuzzy Genetic Algorithm. While comparing with both the results the PSO-PID and genetic algorithm method shows better output as compared to simple PID controller.

REFERENCES

[1] Trapti Yadav, Deepti yadav, Nidhi Singh"Self Tuning PID Controller using Fuzzy Inference Mamdani and Sugeno method on the AVR System". International Journal of Applied Engineering Research ISSN: 0973-4562, Volume 8 No.12, 2013

[2] J. N. Rai, Mayank Singhal, Mayank Nandwani" Speed Control of Dc Motor Using Fuzzy Logic Technique" IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) ISSN: 2278-1676 Volume 3, Issue 6, PP 41-48, 2012

[3] Mohammad Sadegh Rahimian and Kaamran Raahemifar" Optimal PID Controller Design for AVR System using Particle Swarm Optimization Algorithm" Electrical and Computer Engineer Department, Ryerson University Toronto, Ontario, Canada. IEEE CCECE 2011.

[4] Horng-Lin Shieh, Cheng-Chien Kuo, Chin-Ming Chiang" Modified Particle Swarm Optimization Algorithm with Simulated Annealing Behavior and its Numerical Verification" Applied Mathematics and Computation 218, 4365– 4383, 2011.

[5] Adel A. A. El-Gammal, "A Modified Design of PID Controller For DC Motor Drives Using Particle Swarm Optimization PSO" March, 2009.

[6] Girish K. Jha, Ruppa K. Thulasiram, Parimala Thulasiram" Comparison of Adaptive Neuro-Fuzzy and Particle Swarm Optimization based Neural Network Models for Financial Time Series Prediction " asac Niagara Falls, Ontario 2009 .

[7] R. Anulmozhiyal and Dr. K. Baskarn, 'Speed Control of Induction Motor Using Fuzzy PI and Optimized Using GA', International Journal of Recent Trends in Engineering, Vol. 2, No. 5, November 2009

[8] Jin-Sung Kim, Jin-Hwan Kim, Ji-Mo Park, Sung-Man Park, Won-Yong Choe and Hoon Heo 'Auto Tuning PID Controller Based on Improved Genetic Algorithm for Reverse Osmosis Plant', World Academy of Science, Engineering and Technology 47 2008

[9] ASTROM K.J., HAGGLUND T.: The future of PID control‟, Control Eng. Pract., 2001, 9, (11), Author's Profile

[10] Narayan Dutt Pandey Completed B.Tech. in Electrical and Electronics Engineering in 2015 from Sam Higgin Bottom Institute Of Agriculture, Technology And Sciences-Deemed University, M.Tech in control & instrumentation In Sam HigginBottom University Of Agriculture, Technology And Sciences (formerly AAI-DU) Allahabad, India. Area of interest includes control & instrumentation. E-mail id ndp3888@gmail.com.

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[12] L. Raguraman and A. Gnanasaravanan, Performance Optimization and Comparison of Variable Parameter Using Genetic Algorithm Based PID Controller. *International Journal of Electrical Engineering & Technology (IJEET)*, 4(4), 2013, pp. 42–47.

[13] R.P.S. Manikandan and Dr. A.M. Kalpana, Design of Transactional Prediction using Plan Mine and Genetic Algorithms. *International Journal of Computer Engineering and Technology (IJCET),* 7(6), 2016, pp. 50–54.