ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 8, March 2018

Identifying Best Intelligent Tuning Method for Controlling Real Time Level Process among GA and PSO

M. Abimanya[1], A. JeniesWilma[2], V. Bhavani[3], S. M. GirirajKumar[4]

UG Scholar, Department of ICE, Saranathan College of Engineering, Trichy, India[1,2,3]
Professor and Head, Department of ICE, Saranathan College of Engineering, Trichy, India[4]

Abstract: This paper is about tuning PID controller for level process. Here the control strategy includes the tuning of PID controller using Intellectual techniques. The controlling techniques used in this paper are Genetic Algorithm (GA), which is one of the Evolutionary Algorithm that is derived from the searching process simulates the natural evolution of Biological creatures and Particle Swarm Optimization (PSO), is a population based stochastic optimization technique which is mostly similar to the evolutionary technique such as Genetic Algorithm but the PSO has no evolution operators like GA. With these techniques, the controlling of complex process will also be easy. Then the time domain specifications and performance index of these two intelligent methods have been compared using MATLAB.

Keywords: PID controller, linear level process, Particle Swarm Optimization, Genetic Algorithm, MATLAB.

I. INTRODUCTION

With its three-term functionality, proportional, integral and derivative (PID) control offers the simplest and the most efficient solution for many real-world control problems. Its wide application has stimulated and sustained over decades.

In this process of controlling level, both PSO and GA intellectual have been used. Firstly the open loop characteristics of the real time process have been taken for a level process system. For a linear tank, different control tuning methods have been implemented to make the system as effective as possible to obtain the desired output.
Here MATLAB is used to identify and check the Kp, Ki and Kd parameters of the PID controller. By applying that P, I and D values for step input change, a response curve will be produced. From the response, the time domain specification, performance index and robustness of each tuning methods have been compared to identify the best tuning method.
[1] This paper related to controlling the speed of DC motor using Genetic Algorithm. [2] This paper talks tuning method among GA and PSO which one the optimum technique. [14] This paper is about controlling the level process using different tuning methods and identifying the best tuning method. [15] The paper describes about the controller designing for a linear level process system using the intellectual technique Genetic Algorithm and comparing that method with other traditional techniques.

II. INTELIGENT TECHNIQUES FOR PID TUNING

The function of the PID controller is to minimize the value of error produced between set point and the measured process variable.

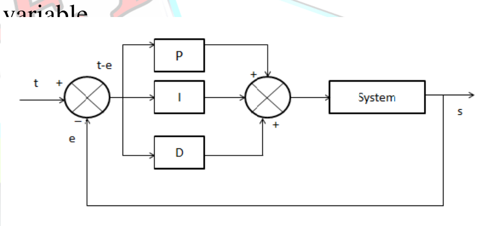

Fig 1.Block diagram of PID Controller

A. PID Controllers

PID stands for Proportional, Integral and Derivative controller. The P, I, D parameters compose the standard three-term controller. These PID parameters as controller are widely used in various process industries. Even in complex industrial control systems make the use of PID controller as their main controller network. With these three parameters PID controller has survived the changes of technology from the analog era into the digital computer control system age in a satisfactory way. PID controller is as type of feedback controller whose output is a control variable (CV), is generally based on minimizing the error

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 8, March 2018

(e) between the set-point (SP) and the measured process variable (PV).

1) Proportional Controller:

In this controller error value is multiplied by a gain, Kp. This is also called as adjustable amplifier. In most of the systems Kp is responsible for process stability. When the process stability is very low then PV can drift away and when it is very high then PV starts to oscillate.

2) Integral Controller:

The integral error is multiplied by a gain Ki. In many systems Ki is responsible for driving error to zero, but when Ki is very high, it is to invite oscillation or instability or integrator windup or actuator saturation.

3) Derivative Controller:

The rate of change of error multiplied by a gain, Kd. In many systems Kd is responsible for system response. If it is too high and the PV will oscillate and if it is too low the PV will respond sluggishly. The designer should also note that derivative action amplifies any noise in the error signal.

B. Introduction to Particle Swarm Optimization

PSO is optimization algorithm based on evolutionary computation technique. It was developed by Kennedy and Eberhartin 1995. The concept of PSO is based on swarm intelligence which has a collective behaviour of decentralized and self-organized system. The natural system of SI includes bird flocking and fish schooling. In PSO system the 'swarm' is initialized with a population of random solutions. Particles fly around in a multi-dimensional search space. The main aim 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 error solution. Like genetic algorithm, PSO does not have evolutionary operator.

i. Generation and initialization of an array of 100 particles with random positions and velocities.
ii. Evaluation of objective function for each particle.
iii. New positions of each particle will be calculated. If a better position is achieved by particle, the pbest value is replaced by the current value.
iv. Searching for another new position of particle. If the new gbest value is better than previous pbest value, the pbest value is replaced by the current gbest value and stored.
v. Update particle's position. The result of optimization is gbest.
vi. Steps (i) and (ii) are repeated until the iteration number reaches a predetermined iteration

C. Flow chart for PSO process

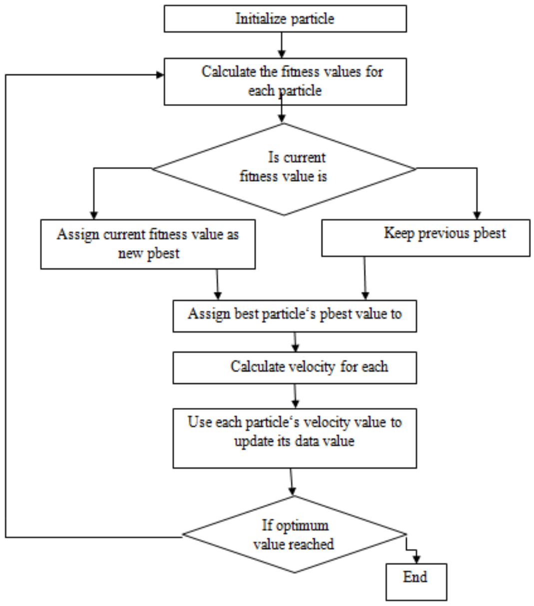

Fig.2 Flow diagram of PSO diagram

D. Genetic Algorithm

Genetic algorithm is one of the global search technique used for the optimization process. It mimics the process of natural evaluation. Genetic algorithms are inspired by Darwin's theory about evolution. Solution to a problem is solved by genetic algorithms. Genetic Algorithm is started with a set of solutions called population. Solutions from one population are taken and used to form a new population. Genetic algorithm represents an intelligent exploitation of a random search used to solve optimization problems. The basic techniques of the GAs are designed to simulate processes in natural systems necessary for evolution; especially those follow the principles first laid down by CharlesDarwin of "survival of the fittest". In nature, competition among individuals for scanty resources results in the fittest individuals dominating over the weaker ones. GA is better than conventional AI in that it is more robust.

E. Implementation Details

This process of natural selection starts with the selection of fittest individuals from a population. They produce offspring which inherit the characteristics of the parents and

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 8, March 2018

will be added to the next generation. If parents have better fitness, their offspring will be better than parents and have a better chance at surviving. This process keeps on iterating and at the end, a generation with the fittest individuals will be found.

Genetic algorithms were implemented through 3 operators:

- Selection that equates to survival of the fittest.
- Crossover which represents mating between individuals.
- Mutation which introduces random modifications.

1) Selection Operator:

- Key idea: offer preference to raised people, permitting them to die their genes to ensuing generation.
- The goodness of every individual depends on its fitness.
- Fitness could also be determined by an objective perform or by a subjective judgment.

2) Crossover Operator:

- Prime distinguished issue of GA from different improvement techniques.
- Two people are chosen from the population mistreatment the choice operator.
- A crossover web site on the bit strings is haphazardly chosen.
- The values of two strings are changed up to the current purpose If S1=000000 and s2=111111 and therefore the crossover purpose is 2 then S1\'=110000 and s2\'=001111.
- The two new offspring created from this mating are put into the next generation of the population by recombining portions of good individuals, this process is likely to create even better individuals.

3) Mutation Operator:

- With some low chance, a little of the new people can have a number of their bits flipped.
- Its purpose is to keep up diversity inside the population and inhibit premature convergence.
- Mutation alone induces a stochastic process through the search house.
- Mutation and choice (without crossover) produce parallel, noise-tolerant, hill-climbing algorithms.

F. Flow chart for GA process

The first stage of genetic algorithm is to create a population, then to optimize the controller gain three strings has to be assigned that consist of P, I & D values .In the evaluation of fitness have to test the solution and come with the best solution which is close to the overall specification of the desired solution. If the fittest solution is converges with the desired solution then it will be consider as optimal solution or if the fittest solution is not converges with the desired value then the GA operators will be executed and next fittest value will be generated. This process is continued until the best solution is obtained.

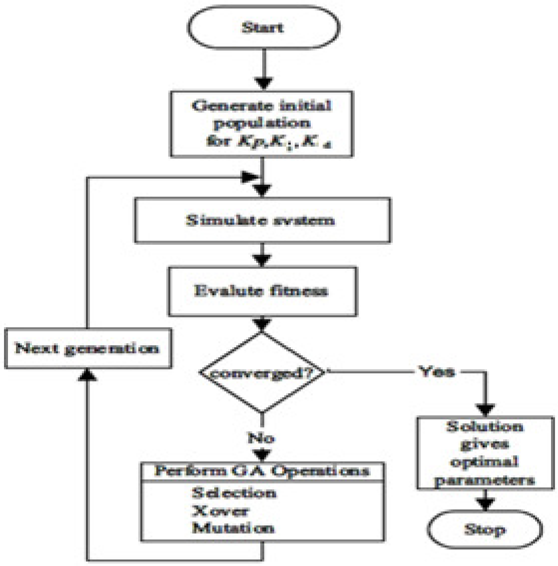

Fig 3.Flow diagram of GA program

III.EXPERIMENTAL SETUP

The Experimental set up shown in figure consists of a linear tank, a water reservoir, centrifugal pump, rotameter and an electro pneumatic converter (I/P converter). The supply for this I/P converter are provided externally. In this setup, a personal computer (PC) loaded with the APEX software allows the user to monitor and control the working process.

Fig.4 Level process trainer kit

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 8, March 2018

SPECIFICATION: Product	Multi-process trainer kit
Product code	326
Control unit	Interfacing unit with ADC/DAC conversion; analog inputs 4,analog outputs1
Communication	RS232
Differential pressure transmitter	Type capacitance, two wire, range 0-200mm, output 4-20mA linear (2 nos)
Level transmitter	Type electronic, two wires, range 0-250mm, output 4-20 mA.
Control valve type	Pneumatic; size ¼'', input 3-15 psig, air to close, characteristics: linear
I/P converter	Input 4-20 mA, output 3-15 psig
Rotameter	10-100 LPH
Pump	Fractional horse power, type centrifugal (2 nos)
Process tank	Transparent, acrylic, with 0-100 %graduated scale
Supply	SS304
Flow measurement	Orifice meter (3nos)
Air filter regulator	Range 0-2.5 kg/cm2
Pressure gauge	Range 0-2.5 kg /cm2 (1 no), range 0-7kg/cm2(1 no)
Overall dimension	425W*500D*1750Hmm
Optional	Mini compressor

IV.RESULT AND DISCUSSION

A. Tuning Parameters

The level process includes the conventional controller and is tuned using non-traditional methods. The tuned GA and PSO results are compared with each other. The tuned parameters were analyzed and the response curves were plotted.

Table 1

Time domain comparison table between GA and PSO

TECHNIQUE	RISE TIME (sec)	SETTLING TIME (sec)	PEAK OVERSHOOT
GA	36	140	0.16
PSO	5	25	0

By comparing the time domain specification between genetic algorithm and particle swarm optimization, PSO is considered as best for this system.

A. Distribution of tuning parameters

Optimization algorithm will be terminated when the maximum number of iterations gets over or with the attainment of satisfactory fitness value. Fitness value is the reciprocal of the magnitude of the objective function.

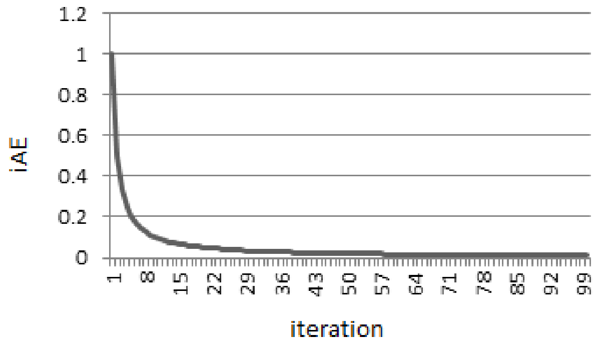

Fig.5. error based on ITAE criterion

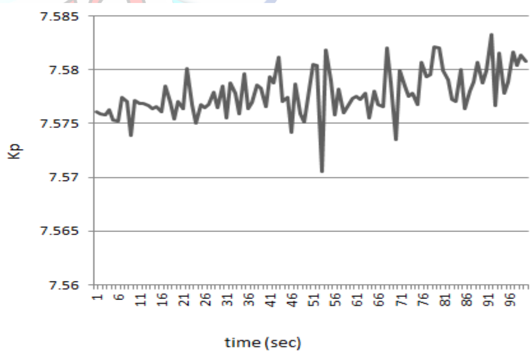

Fig.6.Distribution of Kp for the first iteration

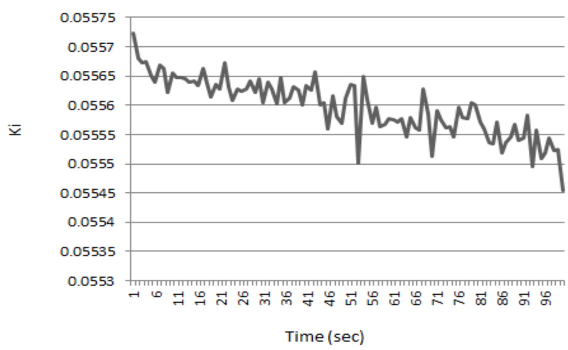

Fig.7 .Distribution of K for the first iteration

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 8, March 2018

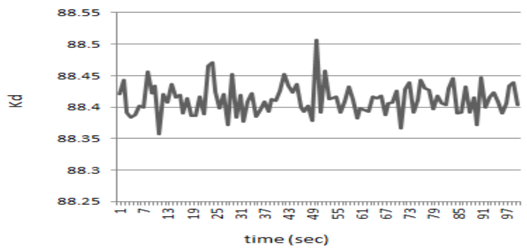

Fig.8.Distribution of Kd for the first iteration

After the first iteration we can get the PID tuning parameter as $K_p = 7.58$, $K_i = 0.0556$, $K_d = 88.4$

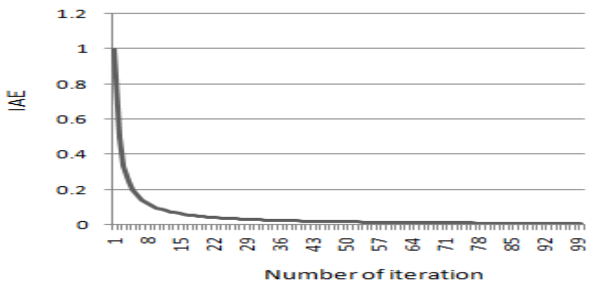

Fig.9 Error based IAE

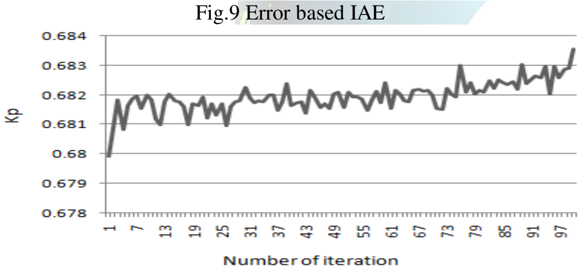

Fig.10 Distribution of Kp

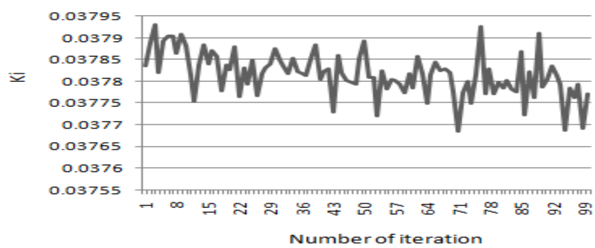

Fig.11.Distribution of Ki

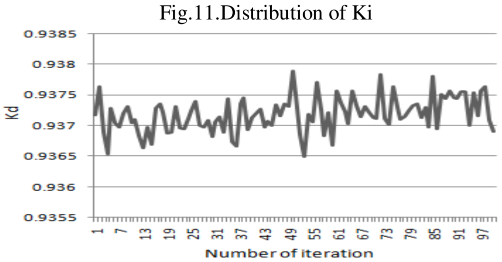

Fig.12.Distribution of Kd

After the first iteration we can get the PID tuning parameter as as K_p=1.257, K_i=0.0683, K_d=2.7662.

B. Performance Index

The integral error is usually accepted as an honest live for system performance. It's helpful to possess criteria that place very little weight on the initial error. These integrals are finite as long as the steady- state error is zero.

The followings are some unremarkably used criteria supported the integral error for a step point or disturbance response:

1. Integral of the absolute value of the error (IAE):

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

2. Integral of the time weighted absolute value of the error (ITAE):

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

3. Integral of the square value of the error (ISE):

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

4. Mean squared error (MSE):

$$MSE = \int_0^{\infty} \frac{1}{n}\sum(yj - \hat{y}j)^{\wedge}2$$

Table.2
The comparison of performance index of tuning methods

ERROR	ITAE	IAE	ISE
PSO	1623	154	632
GA	1640.1	209.53	430

B. Servo and regulatory responses:

The set-point signal is changed and the manipulated variable is adjusted appropriately to achieve the new operating conditions called servo control. Disturbance change - the process transient behavior when a disturbance enters, called regulatory control or load change.

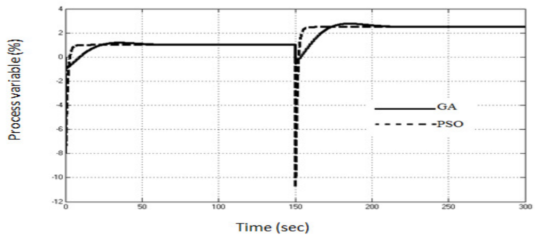

Fig.13. Servo response: GA and PSO. In servo response PSO has settled faster than GA.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 8, March 2018

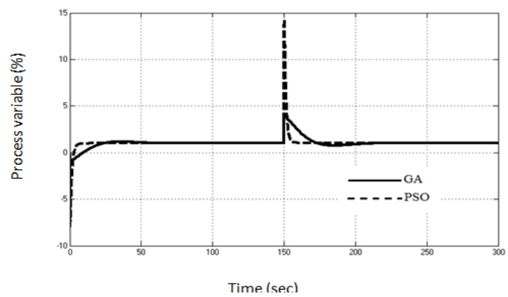

Fig.14. Regulatory response: GA and PSO. In regulatory response after the occurrence of disturbance the PSO has track the set point quickly than GA.

C. *Comparison of Real Time Responses*

By comparing the real time responses of Cohen-coon method and Genetic Algorithm method, the system approximately reaches the set point quickly and maintains in that set point with more accuracy. But in Cohen-coon the deviation from the set point and the settling time is more when compared to GA.

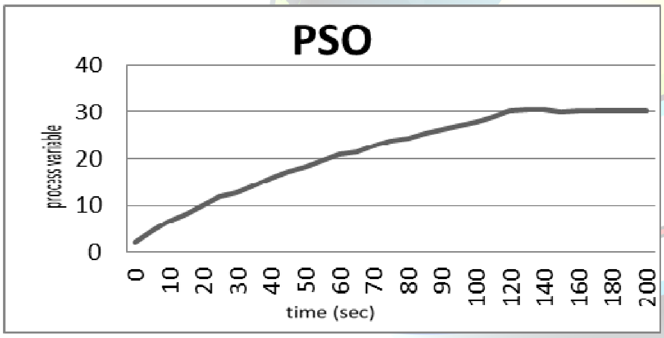

Fig.15. Real time response of the system after tuning using PSO

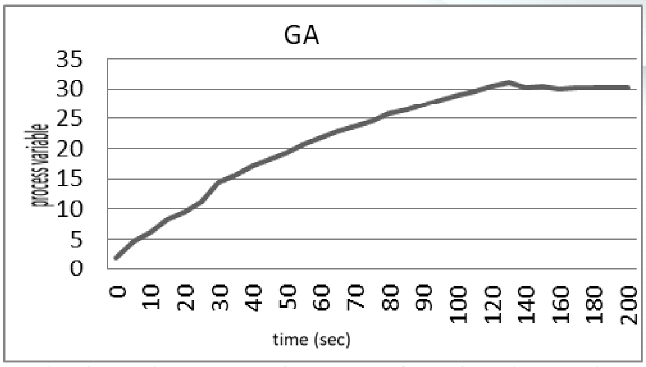

Fig.16. Real time response of the system after tuning using Genetic Algorithm

VII.CONCLUSION

From comparing the time domain specification (table.2.), performance index (table.3.) and servo regulatory response of the given tuning methods shows that PSO is better than GA. Because the rise time, peak overshoot, settling time and error criteria are minimum in PSO and also in the regulatory response it tracks the set point quickly than GA method. Thus from the comparison PSO technique is reliable for this system to control level process.

The comparison is done with the help of MATLAB. PSO is easy to implement and there are few parameters to adjust. PSO has been successfully applied in many areas like function optimization, artificial neural network training, fuzzy system control, and other areas where GA can be applied. Also in the real time response the controller tuned with PSO technique gives better result than GA, this is proved with the help of fig.15 and fig.16.

REFERENCES

[1] Santosh Kumar Suman and Vinod Kumar GiriMadan Mohan Malaviya University of Technology, India "Performance and Analysis of Optimization Techniques for Speed Control of Dc Motor" International Journal of Electronic and Electrical Engineering.,ISSN 0974-2174, Volume 7, Number 2 (2014), pp. 189-194

[2] ShubhamPareek ,MeenakshiKishnani and Rajeev Gupta "Optimal Tuning of PID Controller Using Genetic Algorithm and Swarm Techniques" International Journal of Electronic and Electrical Engineering, ISSN 0974-2174, Volume 7, Number 2 (2014), pp. 189-194

[3] Abhishek Sharma and NithyaVenkatesan," Comparing PI controller Performance for Non Linear Process Model", International Journal of Engineering Trends and Technology- Volume 4, Issue 3- 2013.

[4] M.Lavanya, P.Aravind, M.Valluvan, Dr.B.ElizabethCaroline,"Model Based Control for Interacting And Non-Interacting Level Process Using Labview", International Journal of Advanced Research In Electrical, Electronics And Instrumentation Engineering, Vol. 2, Issue 7, July 2013.

[5] Pushpaveni, S.SrinivasuluRaju, N.Archana, M.Chandana, "Modeling and Controlling of Conical Tank System Using Adaptive Controllers and Performance Comparison with Conventional PID", International T Journal of Scientific & Engineering Research, Volume 4, Issue 5, May-2013.

[6] A.Ganesh Ram & S. Abraham Lincoln, "A Model Reference-Based Fuzzy Adaptive Pi Controller For Non-

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 8, March 2018

Linear Level Process System",International Journal of Research and Reviews in Applied Sciences, Volume 14, Issue 2, February-2013.

[7] P.Aravind, M.Valluvan, S.Ranganathan," Modelling and Simulation of Non Linear Tank", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 2, February 2013.

[8] M. Bandyopadhyay, S. Chattopadhyay and A. Das, "Emphasis on Genetic Algorithm (GA) Over Different PID Tuning Methods of Controlling Servo System Using MATLAB", International Journal of Scientific Research in Computer Science and Engineering Research Paper, Vol-1, Issue-3 E-ISSN: 2320-7639, 2013

[9] Bindu.R, Mini.K.Namboothiripad "Tuning Of PID Controller For DC Servo Motor Using Genetic Algorithm" International journal of emerging technology and advanced engineering, ISSN 2250-2459, vol 2, issue 3, March 2012.

[10] R.Valarmathi, P.R.Theerthagiri, S.Rakeshkumar, "Design and Analysis of Genetic Algorithm Based Controllers for Non Linear Liquid Tank System", IEEE-International Conference on Advances in Engineering, Science and Management (ICAESM -2012) March 30, 31, 2012.

[11] R. Matousek, P. Minar, S. Lang and P. Pivonka, "Efficient Method In Optimal PID Tuning" Proceedings of the World Congress on Engineering and Computer Science, vol 1,WCECS, San Francisco,USA, October,2011.

[12] S. M. G. Kumar, R. Jain, N. Anantharaman, V. Dharmalingam,and K. M. M. S. Begum, "Genetic algorithm based PID controller tuning for a model bioreactor," Indian Chemical Engineer,Indian Institute of Chemical Engineers, vol. 50,no. 3, pp.214–226, 2008

[13] S.M.Girirajkumar, R.Sivashankar, N.Anantharaman, V.Dharmalingam, "Controller using simulated annealing for a real time process", Journal of control theory & applications, April 2008

[14] S.M.Girirajkumar, R.Sivashankar, N.Anantharaman, V.Dharmalingam, Tk.Radhakrishnan, "Genetic algorithm for level control in a real time process", Sensor & transducers journal ,March 2008.

[15] S.M.GirirajKumar, R.Sivashankar, N.Anantharaman, V.Dharmalingam, "Design of controller for a linear system based on Genetic algorithm", Proceedings of National conference on Recent trends in Mechanical Engineering(RTME), Feb 2007.