ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

OPTIMIZATION OF I-PD CONTROLLER PARAMETERS WITH MULTI OBJECTIVE PARTICLE SWARM OPTIMIZATION

[1]S J SUJI PRASAD, [2]R. MEENAKUMARI, [3]P A BALAKRISHNAN

[1]Assistant Professor, Department of EIE, Kongu Engineering College,Erode,India.

[2]Professor, Department of EEE, Kongu Engineering College,Erode,India.

[3]Professor, Department of EEE, Bharathiyar Institute of Engineering for Women,Salem,India.

E-mail: [1]sjsujiprasad@gmail.com , [2] oremkay@gmail.com , [3]pabala52@gmail.com

ABSTRACT

I-PD controller is one of the variants of PID controller that eliminates proportional and derivative kick. In this paper, the effect of I-PD controller with the Multi Objective Particle Swarm Optimization (MOPSO) method for a first order integrating system with delay is presented. The performance of PSO optimized I-PD controller is analyzed with individual objective functions such as; overshoot, rise time, settling time, and compared against integrated multi objective function with weighted aggregation approach. The simulation study reveals that the MOPSO based I-PD controller results in elimination of overshoot, reduction in Integral Square Error (ISE) and Integral Absolute Error (IAE) compared to PSO I-PD with settling time as an objective function.

Keywords: *I -PD Controller, Multi Objective Particle Swarm Optimization (MOPSO), Objective Function, Overshoot, Rise Time, Settling Time.*

1. INTRODUCTION

The PID controllers provide a standard and efficient solution to real-world control problems. Out of forty eight different structures of PID controller, the three primary classifications are the Ideal PID controller, Classical PID controller structure and Non-interacting PID controller structure [1]. The proportional, integral and derivative scheme in conventional PID controller has control action on error. By modifying the structure of the conventional PID controller, the performance can be improved [2]. The drawbacks of conventional PID controller viz., the proportional and derivative kick are reduced by the I-PD controller which is the modified structure of PID controller [3],[4], [5].

Proper tuning of the controller parameters is necessary to achieve the desired performance of the process. Evolutionary optimization techniques like GA (Genetic Algorithm), PSO, BF (Bacterial Foraging), ACO (Ant Colony Optimization) can be used for optimizing the controller parameters [6], [7]. The single objective optimization algorithm may not give the best solution for the controller optimization. So better performance can be achieved by integrating the individual objective functions with proper weights in the I-PD controller. Weighted Aggregation Approach is used in the study of the Particle Swarm Optimization (PSO) in Multi objective (MO) Optimization problems [8].

In this paper, the PSO optimized I-PD controller for a first order integrating system with delay is simulated with overshoot, rise time, and settling time as a single objective function. The performance of I-PD controller can be improved by summing combination of all the three selected objective function in MOPSO.

The remaining section of the paper is organized as follows: I-PD controller structure and the conventional ZN tuning method are explained in section II. Section III deals with the concept of Particle Swarm Optimization (PSO) and Multi Objective Particle Swarm Optimization (MPSO).

Journal of Theoretical and Applied Information Technology
20th August 2014. Vol. 66 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Results are discussed in section IV and section V concludes the findings of the paper.

2. I-PD CONTROLLER AND ZN TUNING

2.1 I-PD Controller

I-PD controller is the modified form of PID controller, in which the integral control scheme works on error e(s) and proportional and derivative control schemes work on measured signal y(s). The structure of I-PD controller is shown in figure. 1.

The Controller output is given by equation(1).

$$c(s) = \left\{\left(\frac{K_p}{T_i s}\right) * e(s) - \left[K_p(1 + T_d s)\right] * y(s)\right\} \quad (1)$$

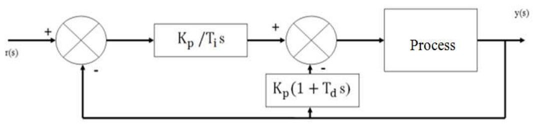

Figure 1: Structure Of I-PD Controller

Since the proportional and derivative actions are taken only upon the process variable, the system responds to the changes in the process variable alone. Thus, this structure reduces the proportional and derivative kick of the error during set point change.

2.2. Process Model and ZN Tuning

Most of the industrial processes have a time delay. A first order integrating system with delay is taken for the analysis [1].
The transfer function model used in this paper is given by (2),

$$TF = \frac{e^{-0.358s}}{s(1 + 1.33s)} \quad (2)$$

The most widely used PID controller tuning method is Ziegler-Nichols Tuning method. The controller parameters are obtained based on the ultimate gain Ku and the period of sustained oscillations Pu. The controller parameters obtained by Ziegler-Nichols Method are given in table 1.

Table 1: Controller Parameters Obtained By Ziegler-Nichols Method

Controller Parameters	Ziegler-Nichols method	
Proportional Gain K_p	0.6 x K_u	1.7469
Integral Time T_i (sec.)	0.5 x P_u	2.2645
Derivative Time T_d (sec.)	0.125 x P_u	0.5661

3. PARTICLE SWARM OPTIMIZATION (PSO) AND MULTI OBJECTIVE PARTICLE SWARM OPTIMIZATION (MOPSO)

3.1 Particle Swarm Optimization

With the known range of controller parameters, PSO is the best suited in finding the optimal values. Based on the results obtained by ZN tuning, the lower and upper bound for the various parameters are fixed which gives the position of the particle. By moving the particles over this range, the optimum value is obtained with respect to the objective function. The position of particle is updated for every iteration based on the personal best and global best [7], [9],[10],[11].

3.1.1 Initialization of PSO parameters

From the previous literatures the initial parameters selected for the system under study is given below,

Size of the Swarm (number of particles)	= 30
No of iterations	= 100
Dimension of the problem space	= 3
Velocity constants C_1 and C_2	= 1.5
Inertia factor	= 1

The flow chart of PSO algorithm is shown in figure. 2.

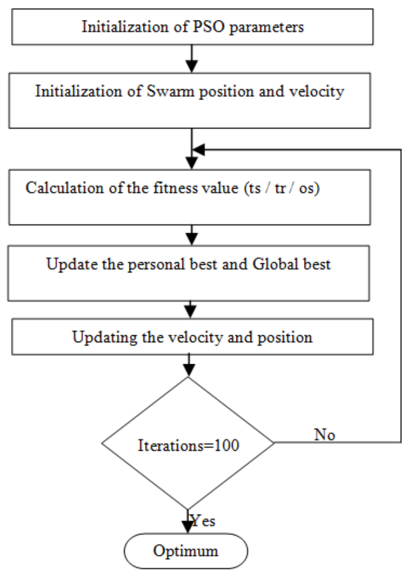

Figure 2: Flow Chart Of PSO Algorithm

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

3.2 Multi Objective Particle Swarm Optimization

In the current scenario, the performance of any complex control system not only depends single parameter but on many. To handle such complex problems, MOPSO based on weighted aggregation is applied associated with suitable weight individual objective function. The objective function is given in (3),

$$F = 0.33 \times ts + 0.33 \times tr + 0.33 \times os \tag{3}$$

4. RESULTS AND DISCUSSION

The response of the I-PD controller with MOPSO optimized controller parameters is analyzed for a step input. Table 2 gives the comparison of the PSO I-PD with individual objective functions and MOPSO weighted aggregation approach. The response of I-PD controller with ZN, PSO and MOPSO parameters is shown in figure 3.

The performance indices such as settling time, rise time, overshoot, Integral Square Error (ISE) and Integral Absolute error (IAE) are tabulated in table 3.

Table 2: Controller Parameters

Optimization method	Controller Parameters		
	Kp	Ti (sec.)	Td (sec.)
PSO I-PD (ts)	4.8282	1.6565	0.5942
PSO I-PD (tr)	6.0427	0.7888	0.6825
PSO I-PD (os)	6.5822	3.5679	0.5006
MOPSO	3.4197	2.2685	0.6301

Table 3: Comparison Of Performance Indices

Performance indices	ts (sec.)	tr (sec.)	os (%)	ISE	IAE
ZN tuning	12.50	02.52	18.52	0.0508	5.7612
PSO I-PD (ts)	**02.62**	01.67	01.61	0.0346	3.1369
PSO I-PD (tr)	06.81	**01.23**	49.74	0.0172	2.2957
PSO I-PD (os)	11.98	02.66	Nil	0.0511	5.4146
MOPSO	05.18	02.12	**Nil**	**0.0226**	**2.0043**

Compared to ZN tuning the PSO I-PD has hands on control in the selected objective function. This controller does not take control actions on other parameters if a single objective function is used whereas MOPSO based weighted aggregation approach the performance indices are highly improved.

5. CONCLUSION

The performance indices of the I-PD controller are improved with the proposed Multi Objective Particle Swarm Optimization for the system under study. The overshoot is eliminated compared to other methods. The settling time and rise time are reduced by 57% and 21%, respectively, compared to PSO I-PD with overshoot as objective function. The integral square error (ISE) is reduced by 35% and integral absolute error (IAE) is reduced by 36% compared to PSO I-PD with settling time as a fitness function. Hence it is concluded that I-PD controller parameter optimization with Multi Objective Particle Swarm Optimization (MOPSO) weighted aggregation approach method outperforms the other tuning methods.

REFRENCES:

[1] Aidan O' Dwyer, 'Handbook of PI and PID Controller Tuning Rules', Second Edition, Imperial College Press, London, 2006.

[2] Qing-Guo Wang, Tong-Heng Lee, Ho-Wang Fung, Qiang Bi, Yu Zhang, 'PID Tuning for Improved Performance', *IEEE Transactions on Control Systems Technology*, Vol. 7, No. 4, 1999, pp. 457-465.

[3] John Thoma, 'Advanced control techniques, examining fuzzy logic and alternative PID control actions on injection molding processes', *IEEE Conference - Forty-sixth Annual conference of Electrical Engineering Problems in the Rubber and Plastics Industry*, April 26-27, 1994, Akron, OH.

[4] Katsuhiko Ogata, 'Modern Control Engineering', Fourth Edition, Prentice Hall, India, 2006.

[5] Rajinikanth, K. Latha, 'I-PD Controller Tuning for Unstable System Using Bacterial Foraging Algorithm: A Study Based on Various Error Criterion', *Applied Computational Intelligence and Soft Computing*, Vol. 2012, article ID 329389, 2012.

[6] B. Nagaraj, P. Vijayakumar, 'A Comparative Study Of PID Controller Tuning Using GA, EP, PSO AND ACO', *Journal of Automation, Mobile Robotics & Intelligent Systems*, Vol. 5, No. 2, 2011, pp. 42-48.

[7] Rania Hassan, Babak Cohanim, Olivier de Weck, 'A Comparison of Particle Swarm Optimization and the Genetic Algorithm', *46th*

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials, April 18-21, 2005, Austin, Texas.

[8] K.E. Parsopoulos, M.N. Vrahatis, 'Particle Swarm Optimization Method in Multi objective Problems', *Proceedings of the ACM 2002 Symposium on Applied Computing* (SAC).2002, pp. 603-307.

[9] Tushar Jain, M. J. Nigam , 'Optimization of PD-PI Controller Using Swarm Intelligence', *International Journal of Computational Cognition*, Vol. 6, No. 4, 2008, pp. 55-59.

[10] Russell C Eberhart, Yuhui Shi, 'Particle Swarm Optimization: Developments, Applications and Resources', *Proceedings of the 2001 Congress on Evolutionary Computation*, 2001, pp. 81-16, Seoul.

[11] Riccardo Poli ,James Kennedy, Tim Blackwell, 'Particle swarm optimization-An overview', *Springer Science Journal of Swarm Intelligence*, Vol.1, No.1, 2007, pp. 33-57.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

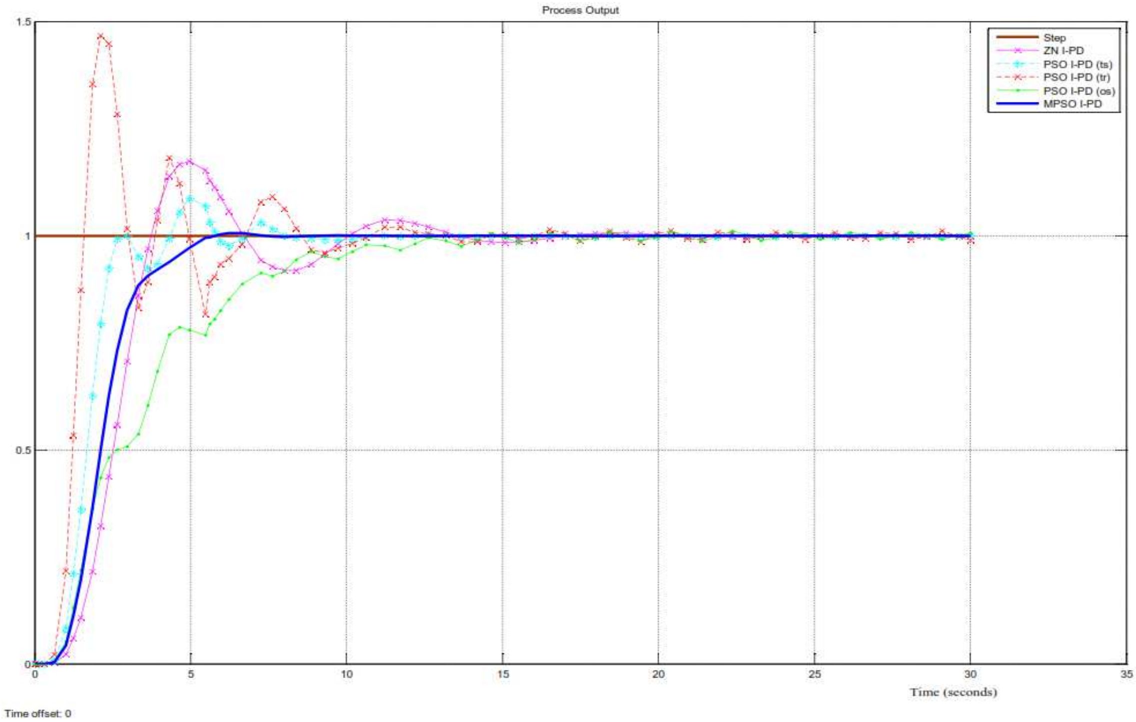

Figure 3: Response of I-PD Controller