International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
International Conference On Emerging Trends in Mechanical and Electrical Engineering
(ICETMEE- 13th-14th March 2014)

RESEARCH ARTICLE OPEN ACCESS

A Review on Tuning of PID controller Using Soft Computing Techniques

Sachin Kumar Mishra, Manoj Kushwaha, M.D. Bhutto
Electrical Engineering Dept.
Madhav Institute of Technology and Science
Gwalior, India
Email- sachinbmas@gmail.com,
manojkushwah1990@gmail.com, mdbhutto786@gmail.com

Kuldeep Swarnkar
Electrical Engineering Dept.
Madhav Institute of Technology and Science
Gwalior, India
Email- kuldeepkumarsony@yahoo.co.in

Abstract
Proportional Integral Derivative (PID) controller is used in industries for wide number of applications. The tuning of PID controller parameters is the very difficult task. PID controllers are widely used as a means of controlling system outputs. Many techniques have been developed to tune the PID parameters. This paper gives the review about various soft computing techniques for tuning of PID controller system. Tuning of the PID parameters continues to be important as these parameters have a great effect on the stability and performance of the control system.
Keywords— PID controller; Tunning; Soft computing techniques.

I. INTRODUCTION

Proportional-Integral-Derivative (PID) controllers are widely used in industry because it can be attributed to its simplicity and effectiveness. To implement PID controller, the gains of PID controller must be determined. Tuning of PID controllers has always been an area of active interest in the process control industry. Great effort has been required to develop methods to reduce the time spent on optimizing the choice of PID controller parameters. There are many tuning techniques based on several methods. These methods can be classified as: i) empirical methods such as the Ziegler -Nichols (ZN) method and the Internal Model Control (IMC), ii) analytical methods such as root locus based techniques, iii) methods based on optimization such as the iterative feedback tuning (IFT). Among these methods, unarguably the ZN method is one of the most well known and popular method. For a wide range of industry processes, ZN tuning method works quite well. However, one of disadvantage of this method is the necessary of the prior knowledge regarding plant model. Once tuned the controller by ZN method a good but not optimum system response will be reached. The transient response can be even worse if the plant dynamics change. It must be noticed that a great amount of plants has time-varying dynamics due to external/environmental causes, to assure an environmentally independent good performance, the controller must be able to adapt the changes of plant dynamic characteristics. Recent years, artificial intelligent techniques-fuzzy logic, neural networks and genetic algorithms (GA) are well established.

Till now many different techniques are proposed to achieve the optimum control parameters for PID controllers. Many new techniques developed for tuning PID controllers. They are not slow in hunting to accomplish the arrive methods based on the evolution principle.

The block diagram for tuning of PID controller with unit feedback for electro hydraulic servo system using soft computing shown in figure 1 [1].

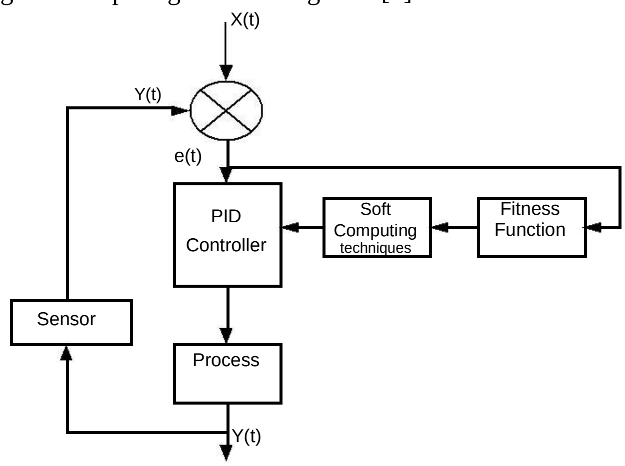

Fig. 1. Block Diagram of Intelligent PID Controller

Equation (1) shows the output of Intelligent PID controller.

$$Y(t) = e(t)\, K_P + K_I \int_0 \;(\,)\; + K_D \frac{de\,(t)}{} \qquad (1)$$

Where

$e(t)$ = Error signal
K_P = Proportional Constant
K_I = Integral Constant
K_D = Derivative Constant

II. SELECTION OF SOFT COMPUTING TECHNIQUE

A. Approximations

Approximations are reruired to apply such that the tuning rules become more simple [2].

B. Model classification

There are many methods which are used to process the different types of model, like first order plus dead time model (FOPDT). We need to reduce the complexity of the model [2].

C. Point of refrence for Designing

These methods are used to tune some point of reference for design such that distinguish the properties of the closed loop system. Some of the points of reference are phase margin and gain, closed loop bandwidth, and non identical cost functions for load changes [2].

The purpose of this paper is to explore many soft computing techniques for parameter tuning of PID controller used in different applications. This is used to improve the performance of PID controller.

III. METHODS OF SOFT COMPUTING TECHNIQUES

Toru yamamoto, et. al [3] proposed the self tuning method of PID controller. It is based on classical control theory, have been widely used for real control system so author consider the control parameter as PID gain of proportional, integral and differential actions. And the control performance depends on these parameters. In this pole-assignment control scheme reported as useful self-tuning control technique for unknown time delay systems.

Bria C. HIon, et. al [4] gives the A self tuning of PID controller has been developed that use the well-known technique of direct-enhance tuning. An objective function that measures the quality of control performance is optimized by a succession of small adjustments to the three PID tuning parameters. Because the optimization is driven by actual performance and no assumptions are made about process dynamics and disturbance behaviour, this technique provides optimal tuning for almost any loop that can be controlled by PID.

Inhyuk Cha, et. al [5] suggests an improved PID control algorithm, which could adjust the control gains automatically. The Extended Kalman Filter (EKF) which based on the Singular Value Decomposition (SVD) is used for the estimation of an unknown or a time-varying parameter and EKF is being used as an observer and the control gains are tuned through EKF. A controller using the EKF has the advantages that the EKF works as an observer and noise jilter concurrently. The suggested controller will be useful in tracking control of a system with time-varying or unknown parameters.

D. Karaboga, et. al [6] suggested PID controller for a process three parameters have to be specified proportional, integral and derivative gain parameters. In order to specify the appropriate values of the parameter in an acceptable time a robust and quick method is required. This letter describes a new method for tuning the control parameters of PID controller. The method is based on the tabu search algorithm which is a general heuristic procedure for guiding search in a complex search space to F d global optimal solutions for difficult problems.

Prashant Mhaskar, et. al [7] propose a two-level optimization-based into account the method for deriving tuning guidelines for PID controllers that take explicitly presence of nonlinear behaviour. The central idea behind the proposed method is the selection of the PID controller tuning parameters so as to best “emulate” the control action and closed-loop response under a given nonlinear controller for a broad set of initial conditions and set-point changes and the first level involves using classical tuning guidelines (typically derived on the basis of linear approximations, running open or closed-lwp tests) to obtain reasonable bounds on the tuning parameters in order to satisfy various design criteria such as stability and performance and robustness. These bounds are in turn incorporated as constraints on the optimization problem solved at the higher level to yield tuning parameter values that improve upon the values obtained from the first level to better emulate the closed-loop behaviour under the nonlinear controller.

Hyung -Soo Hwang, et. al [8] proposed a new tuning algorithm for the PID controller which has the initial value of parameter K_P, K_I, K_D by the Ziegler Nichols formula that uses the ultimate gain and ultimate period from a relay tuning experiment which will get the error and the error rate of plant output corresponding to the initial value of parameter and find the new proportion gain and the integral time from fuzzy tuner by the error and error rate of plant output as a membership function of fuzzy theory so the fuzzy auto tuning algorithm for PID controller considerably reduced the overshoot and rise time as compared to any other PID controller tuning algorithms and real parametric uncertainty systems and also constitutes an appreciable improvement of performance.

Dong Hwa Kim, et. al [9] states that it is very difficult to achieve an optimal PID gain without experience since the parameters of the PID controller has to be manually tuned by trial and error. The authors focus on tuning of the PID controller using immune algorithm and gain/phase margin. After deciding optimal gain/phase margin specifications for the given process, the gains of PID controller using fitness value of immune algorithm depending on error between optimal gain/phase margin and the gain/phase margin obtained by tuning is tuned for the required response.

Rached Dhaouadi, et. al [10] suggested that a self tuning PID controller scheme for nonlinear systems is proposed using wavelet networks and the auto tuner consists of a discrete PID controller and a proposed new wavelet network structure called Dynamic Wavelet Network (DWN). The DWN consists of a static feed forward Wavelet Network in cascade with an autoregressive moving average (ARMA) model. The learning strategy for the wavelet network and PID controller is based on gradient descent and and recursive algorithm is developed to update the weights of the DWN and the parameters of the ARMA model.

J. L. Meza, et. al [11] deals with the problem of optimizing a fuzzy self-tuning PID controller for robot manipulators and Fuzzy PID controllers have been developed and applied in many fields. There is no systematic method to design Membership Functions (MFs) for these controllers. Authors propose a simple method based on Genetic Algorithms (GA) to find optimal input and output MFs of a fuzzy self tuning PID controller. The stability via Lyapunov theory for the closed loop control system is asymptotically stable for a class of gain matrices depending on the manipulator states.

Shan Xue, et. al [12] proposed that the intelligent self-tuning PID controller based on neural network is designed for the system which is nonlinear and does not have mathematical model so designed neural network of the controller can identify the real-time parameters. The intelligent self-tuning PID controller based on neural network is feasible. The difficulties that design the neural network are to determine the number of the layer, the neurons in the hidden layer and the learning rate. To resolve these issues choose MOBP (Back Propagation with Momentum) neural network for tuning of parameter of PID controller.

Yunan Hu, et. al [13] states that on the basis of sufficient analysis on the characteristic of iterative learning control and PID controller parameter tuning work, an idea of applying iterative learning control to PID controller parameter tuning was aroused. Authors choose the linear model in the neighbourhood of character points as the research plant, transforming the problem of PID controller parameter tuning into an open-close loop iterative learning control problem. The stability of PID controller parameters iterative learning control system and the astringency of controller parameters were verified for the first time through the construct of a compress mapping arithmetic operator. The stop condition design scheme of integral type is advanced at the same time.

LV Wenge, et. al [14] says that Election Campaign Optimization (ECO) algorithms used to tune the parameters of PID controller. ECO algorithm is applied to solve the problem of tuning the parameters of PID controllers. It is found that the method developed could determine the optimal parameters, which can bring on a prospective control performance. It indicates that applying ECO algorithm to tune the parameters of PID controllers is an effective method.

Guohan Lin, et. al [15] proposed that many techniques have been developed to tune the PID parameters. Adaptive genetic algorithms (AGA) are proposed as a method for PID optimization and compared with those of traditional optimizations methods. Simulations with different processes show that the gains obtained using adaptive genetic algorithms (AGA) provide better performance than those obtained by the classical Ziegler-Nichols (ZN) method and classical genetic algorithms (CGA) method.

Yanzhu Zhang, et. al [16] state that fractional-order systems model is complex and the fractional-order controller requires more tuning parameters than that of integer-order controller so tuning parameters method of fractional-order PID controller is difficult to obtain. In order to improve the accuracy of fractional-order PID controller character and the designing method of fractional-order PID controller is analyzed and the genetic algorithm is introduced to the design of fractional-order PID controller. By using the genetic algorithm to optimize the corresponding parameters the better PID controller which has a superior is obtained the error of fractional-order controller is avoided and the tuning efficiency is improved. The controlling effect of the fractional-order PID controller is better than that of the integer-order PID controller.

Zou Dexuan, et. al [17] proposed that the robust turning of PID controller is a hard work, and it is restricted by multiple H∞ performance criteria. The robust PID controller turning is essentially a constrained optimization problem therefore a modified global harmony search algorithm (MGHS) is proposed to handle this problem. The MGHS algorithm is a population based algorithm and it updates the worst solutions in each iteration so as to improve the quality of all candidate solutions. The authors combine the MGHS and a penalty function method to trade off the objective function value and constraint violations.

Maryam Khoie, et. al [18] introduces a Genetic -AIS (Artificial Immune System) algorithm is introduced for PID controller tuning using a multi-objective optimization framework. This hybrid Genetic-AIS technique is faster and accurate compared to each individual Genetic or AIS approach and the auto - tuned PID algorithm is then used in an Immune feedback law based on a nonlinear proportional gain to realize a new PID controller. The Immune algorithm presents a promising scheme due to its interesting features such as diversity, distributed computation, adaptation and self monitoring. Simultaneously this leads to a more effective Immune-based tuning than the conventional PID tuning schemes benefiting a multi-objective optimization prospective. Integration of Genetic-AIS algorithm with Immune feedback mechanism results into a robust PID controller which is ultimately evaluated via simulation control test scenarios to demonstrate quick response, good robustness, and satisfactory overshoot and disturbance rejection characteristics.

Xuhua Shi, et. al [19] gives that achieving an optimal PID gain is very difficult for the feedback control loop. Since the gain of the PID controller has to be tuned manually by trial and error, optimisation of the PID controller may not cover a plant with complex dynamics such as large dead time, inverse response, and a highly nonlinear characteristic without any control experience. Author focuses on tuning of PID controller using Gradient immune algorithm. Parameters P, I, and D encoded in antibody are randomly allocated to obtain an optimal gain for robustness based on the time-domain performance indicator.

I. Chiha, et. al [20] states that a tuning PID method based on the multi-objective DE is developed for getting good performances and tunes the optimal PID parameters. In contrast to the single-objective algorithms which try to find a single solution of the problem and the multi-objective technique searches for the optimal Pareto set directly. The aim of the Multi-objective DE algorithm is to determine the optimal solutions of the PID controller parameters by minimization the multi-objective function and to identify Pareto-optimal solution. This method is able to found the optimum solution of the PID controller’s parameters that they allow guaranteeing the performance of the system.

Jiuqi Han, et. al [21] gives a novel tuning method based on Fruit Fly Optimization Algorithm (FOA) is proposed to optimize PID controller parameters. Each fruit fly's position represents a candidate solution for PID parameters. When the fruit fly swarm flies towards one location it is treated as the evolution of each iterative swarm. The main advantages of the proposed method include ease of implementation, stable convergence characteristic, large searching range, ease of transformation of such concept into program code and ease of understanding. The FOA Based optimized PID (FOA - PID) controller is with the capability of providing satisfactory closed - loop performance.

Mohd S. Saad, et. al [22] presents the implementation of PID controller tuning using two sets of evolutionary techniques which are differential evolution (DE) and genetic algorithm (GA). The optimal PID control parameters are applied for a high order system with time delay and non-minimum phase system. The performance of the two techniques is evaluated by setting its objective function with mean square error (MSE) and integral absolute error (IAE). Both techniques will compete to achieve the globally minimum value of its objective functions.

ACKNOWLEDGMENT

Authors would like to thanks Dr. Sanjeev Jain, Director, MITS, Gwalior, M. P. to promoting this work.

CONCLUSION

In this paper, an attempt has been made to review various literatures for the soft computing techniques introduced by the different researchers for tuning of PID controller system to optimize the best result. This review article is also presenting the current status of tuning of PID controller system using soft computing techniques.

REFERENCES

[1.] Mehdi Nasri, Hossein Nezamabadi-pour and Malihe Maghfoori "A PSO-Based Optimum Design of PID Controller for a Linear Brushless DC Motor," World Academy of Science, Engineering and Technology 26 2007.

[2.] Mohd S. Saad, Hishamuddin Jamaluddin and Intan Z. M. Darus, "PID Controller Tuning Using Evolutionary Algorithms," Wseas Transactions on Systems and Control, vol. 7, pp. 139-149, October 2012.

[3.] Toru Yamamoto and Kenzo Fujii "A Self-Tuning PID Controller and Its Application for an Ethylene Cracking Furnace," 0-7803-3685/2/96 $5.00 0 1996 IEEE.

[4.] D. Karaboga and A.Kahnh, "tuning PID controller parameters using tabu search algorithm," 0-7803-3280-6/96/$5.00 O1996 IEEE, pp. 134-136.

[5.] Inhyuk Cha and Changsoo Han "The Auto-tuning PID Controller using the Parameter Estimation," Proceedings of the 1999 IEEE/RSJ International Conference on Intelligent Robots and SFterns.

[6.] D. Karaboga and A.Kahnh "Tuning PID Controller Parameters Using Tabu Search Algorithm," 0-7803-3280-6/96/$5.00 O1996 IEEE, pp. 773-777.

[7.] Prashant Mhaskar, Nael H. El-Farra and Panagiotis D. Christofidest "A Method for PID Controller Tuning Using Nonlinear Control Techniques," Proceeding of the 2004 American Control Conference Boston, Massachusetts June 30. July 2,2004.

[8.] Hyung-Soo Hwang, Jeong-Nae Choi, Won-Hyok Lee and Jin-Kwon Kim "A Method for PID Controller Tuning Using Nonlinear Control Techniques," Proceeding of the 2004 American Control Conference Boston, Massachusetts June 30. July 2,2004.

[9.] Dong Hwa Kim "Comparison of PID Controller Tuning of Power Plant Using Immune and Genetic Algorithms," ClMSA 2003 - International Symposium on Computational Intelligence for Mearurements and Applications Ligano, Switzerland, 29-31 July 2003.

[10.] Rached Dhaouadi, Yousef Al-Assaf and Wissam Hassouneh "A Method for PID Controller Tuning Using Nonlinear Control Techniques," Proceeding of the 2004 American Control Conference Boston, Massachusetts June 30. July 2,2004.

[11.] L. Meza and R. Soto "An Optimal Fuzzy Self-Tuning PID Controller for Robot Manipulators via Genetic Algorithm," 2009 Eighth Mexican International Conference on Artificial Intelligence.

[12.] Shan Xue, Huilin Fan and Hongji Xu "Study on Ann-Based Intelligent Self-Tuning PID Controller," Proceedings of the 2009 IEEE International Conference on Mechatronics and Automation August 9 - 12, Changchun, China.

[13.] Yunan Hu and Jing Li "Iterative Learning Control Based PID Controller Parameter Tuning Scheme Design and Stability Analysis," 978-1-4244-5182-1/10/$26.00 _c 2010 IEEE, pp. 2361-2365.

[14.] LV Wenge, HE Chunhua, CHEN Zeyu, LI Deyuan, CHENG Siyuan, LUO Shaoming and ZHANG Xiangwei "Tuning PID Controller Parameters Optimally Based on Election Campaign Optimization Algorithm," Proceedings of the 29th Chinese Control Conference July 29-31, 2010, Beijing, China.

[15.] Guohan Lin and Guofan Liu "Tuning PID Controller Using Adaptive Genetic Algorithms," The 5th International Conference on Computer Science & Education Hefei, China. August 24–27, 2010.

[16.] Yanzhu Zhang and Jingjiao Li "Fractional-order PID Controller Tuning Based on Genetic Algorithm," 978-1-61284-109-0/11/$26.00 ©2011 IEEE, pp. 764-767.

[17.] ZOU Dexuan, LIU Haikuan and GAO Liqun "A Modified Global Harmony Search Algorithm for Robust PID Controller Tuning," Proceedings of the 30th Chinese Control Conference July 22-24, 2011, Yantai,China.

[18.] Maryam Khoie, Prof. Ali Khaki Sedigh and Dr. Karim Salahshoor "PID Controller Tuning using Multi-Objective Optimization based on Fused Genetic-Immune Algorithm and Immune Feedback Mechanism," Proceedings of the 2011 IEEE International Conference on Mechatronics and Automation August 7 - 10, Beijing, China.

[19.] Xuhua Shi, Ting Lan and JianPing Hu "PID Controller Tuning Using Optimization Based on Gradient-Immune Algorithm," 2012 international conference symposium on instrumentation & measurement ,sensor network and automation (IMSNA).

[20.] Chiha, J. Ghabi and N. Liouane "Tuning PID controller with multi-objective diffrential evolution," Proceedings of the 5th International Symposium on Communications, Control and Signal Processing, ISCCSP 2012, Rome, Italy, 2-4 May 2012.

[21.] Jiuqi Han and Peng Wang and Xin Yang "Tuning of PID Controller Based on Fruit Fly Optimization Algorithm," Proceedings of 2012 IEEE International Conference on Mechatronics and Automation August 5 - 8, Chengdu,China.

[22.] Mohd s. Saad, Hishamuddin Jamaluddin and Intan Z. M. Darus "PID controller tuning using evolutionary algorithms," wseas transactions on systems and control, Issue 4, vol. 7, pp. 139-149, October 2012.