International Journal of Innovative Research in Science and Engineering
Vol. No.3, Issue 02, February 2017
www.ijirse.com
ISSN (O) 2454-9665
ISSN (P) 2454-0663

COMPARISON OF PID CONTROLLER TUNING METHODS FOR FOPDT AND SOPDT OF UNSTABLE SYSTEM

[1]Nidhi Yadav, [2]Chandra Shekhar

[1,2]Chemical Engineering Department DCRUST Murthal, (India)

ABSTRACT

Proportional-integral-derivative (PID) controllers tuning methods reported are based on the approximate plants models derived from the step response. In this paper usually proposed the comparison of different tuning methods for unstable first-order process with dead time(FOUPDT) and second order process with dead time(SOUPDT) system, which gives best condition for controller response. Methods are compared each other i.e. Ziegler-Nichols method (Z-N) [6], C.T.Huang and Y.S.Lin (H-L) [2], Shamsuzzoha and Lee (S-L) [1], Q.Wang, C.Lu and W.Pan (W-P) [4], Poulin and Pomerleau (P-P) [3], Tayrus and Luyben (T-L) [10].Finding the response of given methods compared in both cases FOUPDT and SOUPDT.

Keywords: PID Controller, FOUPDT, SOUPDT, IAE, ISE, ITAE, Tuning, Dead Time, Time Constant.

I. INTRODUCTION

Proportional-integral-derivative (PID) controller has remained as commonly used controllers in industrial process control for 50 yr. even though great progress in control theory. This is because it has a simple structure and is easily understood by the control engineers (Luyben, 1990). As early as 1942, Ziegler and Nichols (1942) proposed the first PID tuning method. It is still widely used in practice at present. While high performance is always the design target in industrial control applications and the Ziegler-Nichols method is insufficient in such applications.A survey of [9]Kano and Ogawa shows that the ratio of applications of a different type of controller, for example, PI/PID control, conventional advanced control is about 100:10:1. On the basis of a survey of more than 11,000 controllers in the process industries, [8] Desborough and Miller reported that more than 97% of the regulatory controllers utilize the PI/PID algorithm.The PI/PID controller has only few adjustable parameters, and are difficult to be tuned properly in real processes. One reason is that tedious plant tests are required to obtain improved controller settings. Because of this reason, finding a simple PI/PID tuning approach with a significant performance improvement has been an important research issue for process engineers.[7] Recently, to determine the parameters of the controller, many design methodology, such as gain margin/phase margin technique, pole placement technique, optimization technique, direct synthesis technique, internal model control technique, equating coefficient technique and robust loop shaping, have been reported in literature. There still exist many unstable processes in the chemical plants, even though most chemical processes are open-loop stable. The common example of unstable system is the batch chemical reactor, which has a strong nonlinearity due to the heat generation term in the energy balance. In general, two type of dead time unstable processes are FOUPDT and SOUPDT, (Huang & Lin, 1995) [2].

$$\text{FOUPDT:}\ \ G(s)=\frac{Ke^{-\theta s}}{(\tau s-1)}$$

$$\text{SOUPDT:}\ \ G(s)=\frac{Ke^{-\theta s}}{(\tau_1 s-1)(\tau_2 s+1)}$$

In this paper comparison of Ziegler-Nicolson method (1942) [6], C.T. Huang and Y.S. Lin (1997) [2], Shamsuzzoha and Lee (2007) [1], Q. Wang, C. Lu and W. Pan (2015) [4]methods are used for FOUPDT and Ziegler-Nicolson method(1942) [6], Tayrus and Luyben method (1958) [10], Huang and Lin method(1995) [2], Poulin and Pomerleau methods (1996) [3] are used for SOUPDT have been done using MATLAB. For finding the best controller tuning method which gives better and higher stability for the process system.

II. GENERALISED FORM OF PID CONTROLLER

A PID controller is designated by:

$$G(s)=K_P+\frac{K_I}{s}+K_D s$$

$$G(s)=K_P(1+\frac{1}{\tau_I s}+\tau_D s)$$

Where, K_P =Proportional Gain, K_I =Integral Coefficient, K_D =Derivative Coefficient, τ_I =Integral action, τ_D =Derivative action.

For the best performance of the system, need to adjust these three parameters called controller tuning.

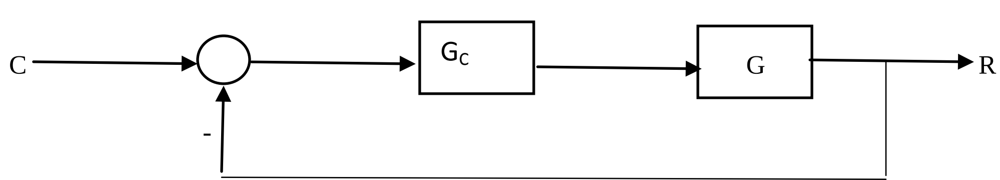

Fig.1 A Classical Feedback Diagram

III. SIMULATIONS

All simulations in this paper were performed using MATLAB 4.0 (control system design and simulation software) (Shahian & Hassul, 1993) [11]. There example consider for both FOUPDT and SOUPDT for studying the controller tuning methods and result of each method is shown below separately. Comparison of each method given in graph in form output of the process. Unit step change are consider for regulatory problems.

Examples,

For FOUPDT, The Following process considered [1] (Shamsuzzoha and Lee, 2007)

$$G(s)=\frac{1.e^{-0.4s}}{1.s-1}$$ (Step input of magnitude 1 at t=20sec given for the process)

Table given below show the controller parameters value calculated by different methods,

S.No.	Method	K_C	τ_I	τ_D
1	Ziegler – Nicolson	1.9647	0.95	0.2375
2	C.T. Huang and Y.S. Lin	2.520	1.65	0.191
3	Shamsuzzoha and Lee	2.62	1.08	0.214
4	Q. W.Changhou and L.W.Pan	2.21	1.01	0.17

Table 1

For SOUPDT, The Following process considered [2] (Huang & Chen, 1997)

$$G(s)=\frac{1e^{-0.939s}}{(5s-1)(2.07s+1)}$$ (Step input of magnitude 1 at t=200 sec given for the process)

Table given below show the controller parameters value calculated by different method,

S.No.	Method	K_C	τ_I	τ_D
1	Ziegler – Nicolson	1.8882	0.14285	1.75
2	Tayrus-Luyben	1.45	0.032	2.22
3	Hung and Lin	3.954	0.2016	2.074
4	Poulin and Pomerleau	3.050	0.1323	2.070

Table 2

ISSN (O) 2454-9665
ISSN (P) 2454-0663

IV. ROBUSTNESS ANALYSIS

For FOUPDT,

S.No.	Method	IAE	ISE	ITAE
1	Ziegler – Nicolson	3.702	3.287	9.054
2	C.T. Huang and Y.S. Lin	4.446	4.098	13.01
3	Shamsuzzoha and Lee	2.462	2.408	3.813
4	Q. Wang, C. Lu and W.Pan	3.07	3.064	5.664

Table 3

For SOUPDT,

S.No.	Method	IAE	ISE	ITAE
1	Ziegler – Nicolson	43.47	38.15	1324
2	Tayrus-Luyben	49.79	62.91	1201
3	C.T.Huang and Y.S.Lin	37.03	22.38	1400
4	Poulin and Pomerleau	16.96	12.79	245.2

Table 4

V. SIMULATION RESULTS

Figure 2 and 3 shows PID controller performance by each considered method and comparison of these method for FOUPDT system.

Figure 4 and 5 shows PID controller performance by each considered method and comparison of these method for SOUPDT system.

For FOUPDT,

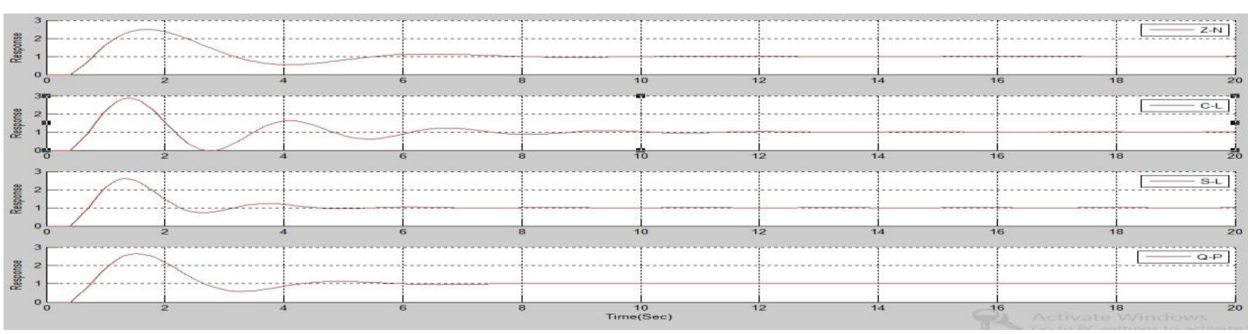

Fig. 2

International Journal of Innovative Research in Science and Engineering
Vol. No.3, Issue 02, February 2017
www.ijirse.com
ISSN (O) 2454-9665
ISSN (P) 2454-0663

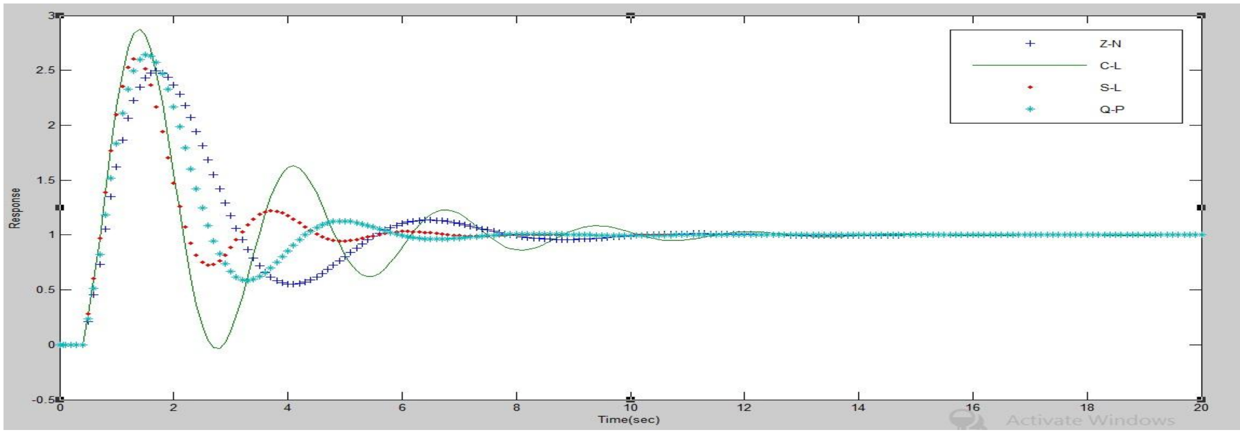

Fig. 3

For SOUPDT,

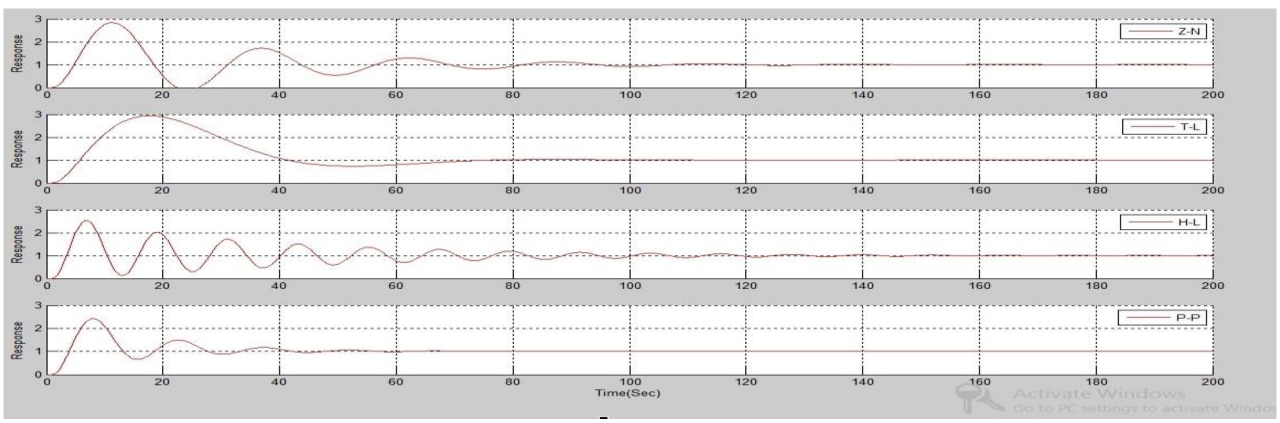

Fig. 4

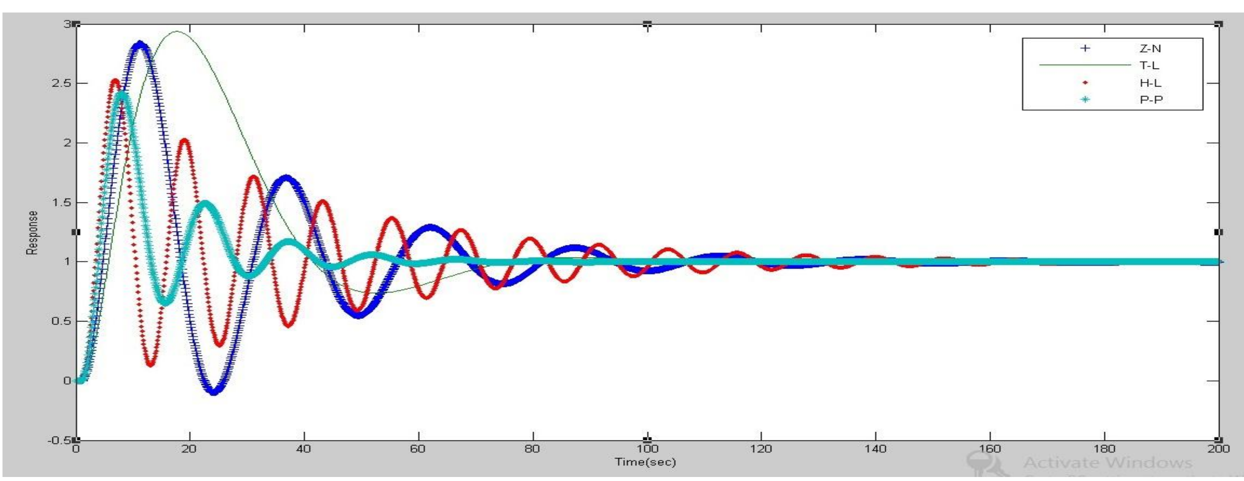

Fig. 5

Time Domain Analysis [5],

System	FOUPDT				SOUPDT			
Method	Z-N	H-L	S-L	Q-P	Z-N	T-L	H-L	P-P
Rise Time	0.833	0.833	0.834	0.836	4.5	5.667	3.33	3.66
Settling Time	45.67	30	30	20	260	180	400	193.33

VI. RESULTS AND DISCUSSION

Controller parameters are calculated by tuning, these parameters make inverse effect to each other for optimum value of controller. Different method are used for controller design which gives good stability of the controller response. Time domain analysis shows rise and settling time of controller, minimum rise and settling time needed for good response of controller.

VII. CONCLUSION

PID controller designed for FOUPDT and SOUPDT by different controller tuning methods. All methods are worked in direction of settling the process variable to a desired set value. IAE, ISE and ITAE are very minimum by Shamsuzzoha and Lee method as compared to other controller tuning methods for FOUPDT system this shows that this method gives very good response and robust response of controller for first order unstable process without taking too much time and oscillation for attain stability of the system. For SOUPDT, IAE, ISE and ITAE are very minimum by Poulin and Pomerleau method as compared to other controller tuning method this shows this method gives very good and robust response of controller for second order unstable process without taking too much time and oscillation for attain stability of the system.

VIII. ACKNOWLEDGEMENT

The authors is very thankful to TEQUIP-II, funds available in university for providing financial support in presenting this paper.

REFERENCES

1. Shamsuzzoha, M.; Lee, M.*IMC-PID controller design for improved disturbance rejection of time delayed processes; Ind. Eng. Chen. Res.2007; 46, 2077-2091.*
2. Huang, C. T., & Lin, Y. S. *Tuning PID controller for open-loop unstable processes with time delay. Chemical Engineering Communications, 1995;133, 11.*
3. Poulin, ED., & Pomerleau, A.*PID tuning for integrating and unstable processes. IEE Process Control Theory and Application, 1996; 143(5), 429.*

4. Qing Wang, Changhou Lu, Wei Pan, *IMC PID controller tuning for stable and unstable processes with time delay, Chemical Engineering Research and Design, 2015; 42.*
5. Seborg, Edgar, Mellichap, Doyle *Process Dynamics and control;*2011; Edition 3rd page no. 223-225.
6. Donald R. Coughanour,*Process System Analysis and Control;1991;*Edition 2ndpage no. 54
7. Yongho Lee, Jeongseok Lee, Sunwan Park, *PID controller tuning for integrating and unstable processes with time delay Chemical Engineering Science;1999; 55(2000) 3481-3483.*
8. Desborough, L. D.; Miller, R. M. *Increasing customer value of industrial control performance monitoringHoneywell's experience;Chemical Process Control −VI (Tuscon, Arizona, Jan. 2001). AIChE Symp. Ser. No. 326. 2002, 98.*
9. Kano, M.; Ogawa, M. *The state of art in chemical process control in Japan: Good practice and questionnaire survey. J. Process Control 2010, 20, 969−982.*
10. Tyreus, B. D.; Luyben, W. L. *Tuning PI controllers for integrator/dead time processes. Ind. Eng. Chem. Res. 1992, 2625−2628.*
11. Shahian, B., & Hassul, M. *Control system design using MATLAB. Englewood Cli!s, 1993; NJ: Prentice Hall.*