Journal of Electrical Engineering & Technology (JEET)
Volume 3, Issue 1, January- December 2018, pp. 1–6, Article ID: JEET_03_01_001
Available online at http://www.iaeme.com/JEET/issues.asp?JType=JEET&VType=3&IType=1
ISSN Print: 2347-422X and ISSN Online: 2347-4238
Journal Impact Factor (2016): 1.8072 (Calculated by GISI) www.jifactor.com

DESIGN AND ANALYSIS OF TUNING TECHNIQUES USING DIFFERENT CONTROLLERS OF A SECOND ORDER PROCESS

J.K. Moharana
Department of EEE, GITA, BBSR, Odisha, India

ABSTRACT

There are several methods that through the PID (Proportional Integral Derivative) can generate automatic control. In this work are used particularly two methods, the Ziegler-Nichols and Cohen-Coon that are applied to a team of control for industrial processes. These two methods are programmed to control the level, the flow, the pressure and temperature of a certain amount of fluid contained in a warehouse transparent. Since not all methods are efficient to control with accuracy certain parameters, they are looking know which of these two methods is more efficient to control these parameters, or for a given parameter, which method is more appropriate.

Keyword: Tuning process, controller, Ziegler-Nichols Method, second-order system.

Cite this Article: J.K. Moharana, Design and Analysis of Tuning Techniques Using Different Controllers of a Second Order Process: *Journal of Electrical Engineering & Technology*, 3(1), 2018, pp. 1–6.
http://www.iaeme.com/JEET/issues.asp?JType=JEET&VType=3&IType=1

1. INTRODUCTION

The timing by means of control PID is very important, is already in many of the different technologies of our environment. Since the cars we handle daily until the nuclear reactors electricity generators. In this case apply control to a team of industrial processes to which it is called controlled system. The variable out or real x value of this team is parameters that want to keep controlled in a desired value w. When it is a difference between the real value x and the desired value w, the driver will lead to the system toward the desired value. The parameters are programmed with the methods of tuning Ziegler-Nichols and Cohen Coon. This method will provide two forms of compare which of these is more convenient to use when you want to control a parameter.

To make the experiments use training equipment composed of industrial equipment RT-578. This team has a deposit transparent in which regulates the level and the pressure, a piping system for regulating the flow, and a system of two circuits with heat exchanger plates for the temperature regulation.

2. METHOD OF ZIEGLER-NICHOLS

Ziegler and Nichols suggested two methods of tuning to determine the values of the gain proportional (Kp), the time integral (Ti) and the time derivative (Td) on the basis of transient response from a specific methods so-called tuning of Ziegler-Nichols.

2.1. First method (Curve of reaction)

In the first method, the response of a plant before an entry step is obtained from an experimental basis. The response curve step unit takes the form of S if the plant does not contain integrators nor poles dominant complex conjugates. This curve is characterized by two parameters: the delay time (L) and the time constant (T) as shown in Fig.1. If the answer is not a curve in the form of S is not advisable to use this method.

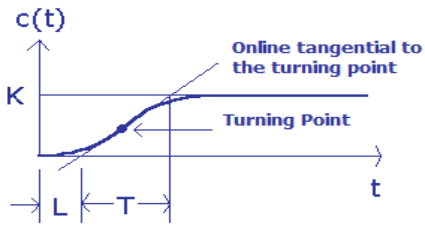

Figure 1 Ziegler-Nichols curve

In this case the role of transfer is approaching through a system of the first order with a delay of transport as shown below:

$$\frac{C_{(s)}}{U_{(s)}} = \frac{Ke^{-Ls}}{Ts+1}$$

In the first method, Ziegler and Nichols established the values of Kp, Ti and Td in accordance with the formula that appears in the following Table.I.

The driver PID tuned through the first method of the rules of Ziegler-Nichols produces:

$$G_{c(s)} = K_p\left(1 + \frac{1}{T_i s} + T_d s\right)$$

$$G_{c(s)} = 1.2\frac{T}{L}\left(1 + \frac{1}{2Ls} + 0.5Ls\right) = 0.6T\frac{\left(s + \frac{1}{L}\right)^2}{s}$$

Therefore, the driver PID has a pole in the origin and a double zero in S=-1/L.

Table I Ziegler and Nichols established controller parameters for first method

Type of controller	K_p	T_i	T_d
P	$\frac{T}{L}$	∞	0
PI	$0.9\frac{T}{L}$	$\frac{L}{0.3}$	0
PID	$1.2\frac{T}{L}$	2L	0.5L

2.2. Second method (Oscillation continuous)

In this method, first outlined the values of Ti= and Td=0. Subsequently, using only the action proportional control increases the value of Kp from zero to a critical value where the exit show sustained oscillations. If such an exit shows no oscillations sustained for any value of Kp, this method cannot be applied. Therefore, the gain and the critical period are determined experimentally. Ziegler and Nichols suggested that the values of the parameters Kp, Ti and Td in accordance with the formula the following Table.II.

Table II Ziegler and Nichols established controller parameters for second method

Type of controller	K_p	T_i	T_d
P	$0.5K_{cr}$	∞	0
PI	$0.45K_{cr}$	$\frac{1}{1.2}P_{cr}$	0
PID	$0.6K_{cr}$	$0.5P_{cr}$	$0.125P_{cr}$

The driver PID tuned through the second method of Ziegler-Nichols produces:

$$G_{c(s)} = K_p\left(1 + \frac{1}{T_i s} + T_d s\right)$$

$$G_{c(s)} = 0.6K_{cr}\left(1 + \frac{1}{0.5P_{cr}s} + 0.125P_{cr}s\right) = 0.075K_{cr}P_{cr}\frac{\left(s + \frac{4}{P_{cr}}\right)^2}{s}$$

Therefore, the driver PID has a pole in the origin and double zero in s=-4/Pcr.

The rules of tuning Ziegler-Nichols apply only to the plants whose dynamic is known. The rules developed by Ziegler and Nichols are the most used in the tuning drivers PID, when it is difficult to obtain the mathematical model of his plant to which he requires some kind of control. These rules of tuning require initially an experimental stage where the engineers in charge of the development of the controller PID, must specify the response that generates the plant and with it determine the driver appropriate, if that can be applied the methods of Ziegler -Nichols.

2.3. Method of cohen-coon (Reaction)

Cohen and Coon were the first to observe that for most of the processes controlled, the curve of a reaction may be approximate to the response of a system of the first order with time died. This requires of the estimate of a gain stationary, a time constant effective and a time dead cash to characterize the process and get a response that comes close very closely to the curve of reaction of the current process. Cohen and Coon also developed rules of tuning with the aim of achieving replies with a reason decay of a fourth. However, as this criterion does not provide a single set of parameters of tuning, the rules of Cohen-Coon estimated values different from those encountered by Ziegler and Nichols, as shown in the following Table.III.

Table III Controller parameters for Method of cohen-Coon

controller	K_c	τ_I	τ_D
P	$\frac{1}{K}\left(\frac{\tau}{t_o}\right)\left[1+\frac{1}{3}\left(\frac{t_o}{\tau}\right)\right]$		
PI	$\frac{1}{K}\left(\frac{\tau}{t_o}\right)\left[0.9+\frac{1}{12}\left(\frac{t_o}{\tau}\right)\right]$	$t_o\left[\frac{30+3\left(\frac{t_o}{\tau}\right)}{9+20\left(\frac{t_o}{\tau}\right)}\right]$	-
PD	$\frac{1}{K}\left(\frac{\tau}{t_o}\right)\left[\frac{5}{4}+\frac{1}{6}\left(\frac{t_o}{\tau}\right)\right]$		$t_o\left[\frac{6-2\left(\frac{t_o}{\tau}\right)}{22+3\left(\frac{t_o}{\tau}\right)}\right]$
PID	$\frac{1}{K}\left(\frac{\tau}{t_o}\right)\left[\frac{4}{3}+\frac{1}{4}\left(\frac{t_o}{\tau}\right)\right]$	$t_o\left[\frac{32+6\left(\frac{t_o}{\tau}\right)}{13+8\left(\frac{t_o}{\tau}\right)}\right]$	$t_o\left[\frac{4}{11+2\left(\frac{t_o}{\tau}\right)}\right]$

Interestingly, more than half of the industrial controllers used today used control schemes PID or PID amended. The drivers PID analog are mainly type hydraulic, pneumatic, electronic, and electrical or its combinations. Apply the second method of Ziegler-Nichols to our plant:

$$G(s) = \frac{0.8}{30s^3 + 43s^2 + 14s + 1}$$

Which was obtained by mean training equipment RT-578, shown in Fig.2 below, where it try to control the water level at set-point.

Figure 2 Equipment of RT-578

We know the critical gain is $Kcr = 23$. Knowing this parameter, we can to compute the critical period Pcr based in the next Table.IV:

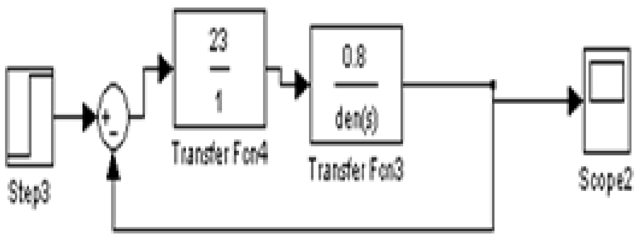

Figure 3 Control Block Diagram

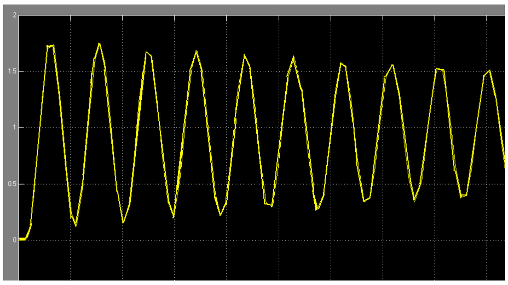

Figure 4 Output of controller

From it figure; we can obtain the parameter $Pcr = 9.1666667$.

On the other hand, we have at the next table; how we can compute Kp. Ti and Td to different controllers PID´s.

Table IV Designed controllers parameter

Controllers	Kp	Ti	Td
P	11.5	∞	0
PI	10.35	7.638889	0
PID	13.8	4.583334	1.14583

Now, we have the simulations about it for the controllers P, PI and PID´s. It use Simulink of Matlab. Then, its result obtained for each controller as shown in Fig.6:

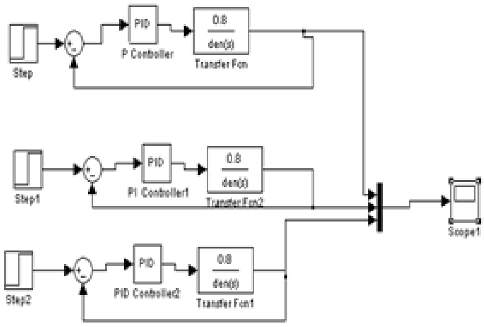

Figure 5 Simulink Block Diagram

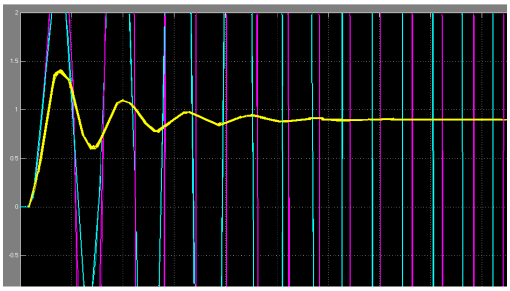

Figure 6 Step output

3. SUMMARY

We can see, only the P controller reach the stability. The controllers PI y PID don´t never reach the stability, because the output is maintained at oscillating, then we can to say the P controller is the best. This way, we can use the Ziegler-Nichols method first and we have a good stability. The stability time is about 70 seconds.

REFERENCES

[1] Modern Control Engineering. - Ogata Katsuhiko – Ed. Prentice Hall.

[2] Manual de Experimentos. - RT-578 Equipo de control de proceso industrial.

[3] Advanced PID Controllers. - Astrom, K. J.

[4] Smith, O.J. M., "Closer Control of Loops with Dead Time", Chem. Eng. Progress, 53(5), 217-219, 1957

[5] Terry Blevins, "Modifying the Smith Predictor for an Application Software Package" , ISA 1979 Annual Conference.

[6] Astrom , T. Hagglund, "PID Controllers: Theory, Design, and Tuning", ISA, 1995, pp. 156-159.

[7] F.G. Shinskey, "Model Predictors: The First Smart Controllers", I&CS, September, 1991, pp. 49-52.

[8] Hagglund, "An industrial Dead-Time Compensating PI Controller", Control Eng. Practice, Vol.4, No. 6, pp. 749-756

[9] Willy Wojsznis, "Variable Horizon Predictor", 33rd IEEE CDC, Lake Buena Vista, Florida, 1994.

[10] Willy Wojsznis, Michael Ott, "Predictive Control Implementation Into DCS Controller", Advances in Instrumentation and Control, Volume 49, Part 3, pp. 767.