International Journal of Electronics Engineering Research.
ISSN 0975-6450 Volume 9, Number 6 (2017) pp. 809-814

http://www.ripublication.com

Auto-tuning of PID Controller for the Cases Given by Forbes Marshall

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Abstract

In this paper, an algorithm for relay auto-tuning of the proportional-plus-integral-plus-derivative (PID) controller is implemented. Auto-tuning is a method where the controller is tuned automatically on demand from a user during starting phase of the process or when any disturbance is occurred. An automatic tuner evaluates process behaviour for a given input and provides values for controller parameters. The PID controller is auto-tuned to obtain desired performance specifications. The objective of this paper is to simulate each control in software and also on the actual site and get trends which will show before and after performance trends of implementation at low cost.

Keywords: PID controller, Relay, Auto-tuning

I. INTRODUCTION

The proportional-plus-integral-plus-derivative (PID) controllers have found wide acceptance and applications in the industries for the past few decades. However, audits show that paper mills in Canada having typical mill has more than 2000 control loops and that 97% of them use PI control [2] .Only 20% of the control loops were found to work well and decrease process variability. One of the reasons for poor performance was poor tuning (30%).Further comments on the performance and robustness of well-known PID tuning methods are given which shows a need for simple and effective tuning methods [3]. The technique of relay auto-tuning of PID controllers has been proposed to automate the Ziegler–Nichols ultimate cycling tuning method [1] [4].

In Ziegler-Nichols closed loop tuning, the process variable may go into unstable region while obtaining value of P controller for which oscillations with steady state amplitude and frequency could be obtained. In the case of relay auto-tuning this oscillations of the process can be confined within desired safety limits and process behaviour can be analyzed.

II. PROCESS – Level control loop

In the feedback level experiment, the water from sump tank is pumped into the level tank through the pneumatic control valve as shown in fig (a). A capacitance level probe is inserted into the level tank where the change in capacitance takes place as the water level in the tank changes. A suitable signal conditioning circuit converts the change in capacitance into standard current signal (4-20 mA) via level transmitter, which is fed to the controller. PID controller compares the input signal measured variable (mV) with the set point & calculates error signal (e).

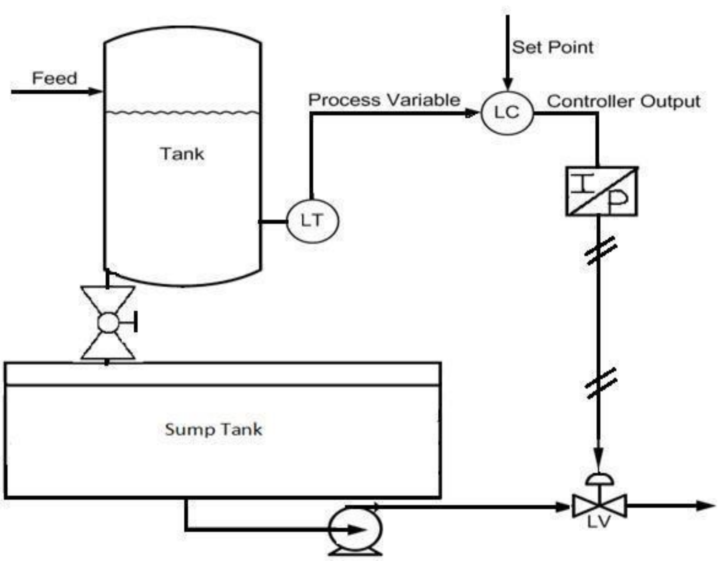

Fig. (a) Level control loop

The output of the controller (4-20 mA) is given to the electro-pneumatic converter, which converts electrical signal into the pneumatic one (3-15 psi). This pneumatic signal is fed to the pneumatic actuator (diaphragm) which activates the final control element i.e. control valve by controlling its opening according to the input given & the flow is manipulated. As per the manipulation of flow the level in the tank is controlled. This process goes on till the error becomes zero & output stabilizes that means actual level or measured variable matches with the set value or set point. The system becomes stable until the disturbances is inserted manually or generated by default.

III. RELAY AUTO-TUNING

A block diagram of an auto- tuner based on the relay method is shown in fig. (b). A switching action takes place in between auto-tuner and controller. When it is desired to tune the system, the PID function is disconnected and the system is connected to relay control. The process variable starts to oscillate.

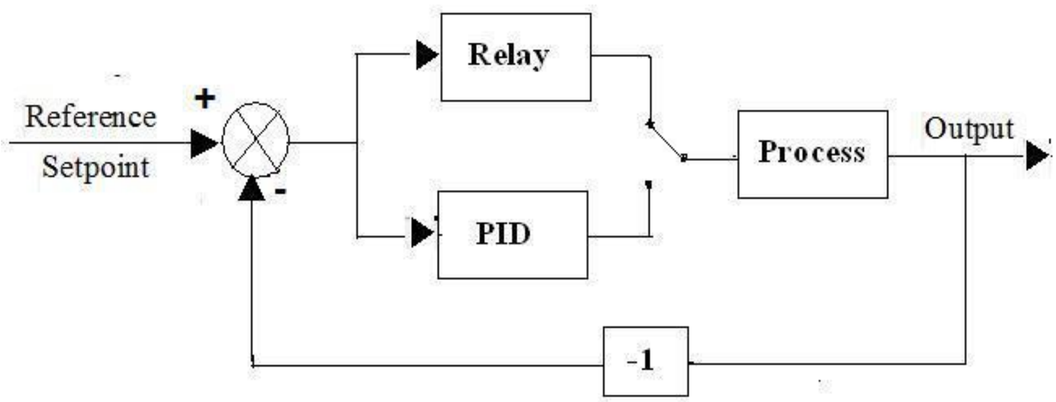

Fig. (b) Relay auto-tuner

When the oscillations are obtained, period and the amplitude of the oscillations are determined. This gives the ultimate period and the ultimate gain. Using these values of period and amplitude, the parameters of a PID controller can be determined, e.g., using the Ziegler-Nichols closed loop tuning method. The PID controller is then automatically switched in again, and the control is executed with the new PID parameters.

A .THE RELAY METHOD

As shown in fig (c), both Input and Output are in steady state. The Output is stepped in one direction by some distance D. As soon as the Input crosses a trigger line, the output changes to the other direction by distance D. By analysing how far apart the peaks are, and how big they are in relation to the output changes, the Auto tuner can tell the difference between one type of process and another. The process behaves different for different set points. Therefore, we get different amplitude and different period for set points. We have performed relay auto tuning for 3 different set pints and various values of controller parameters.

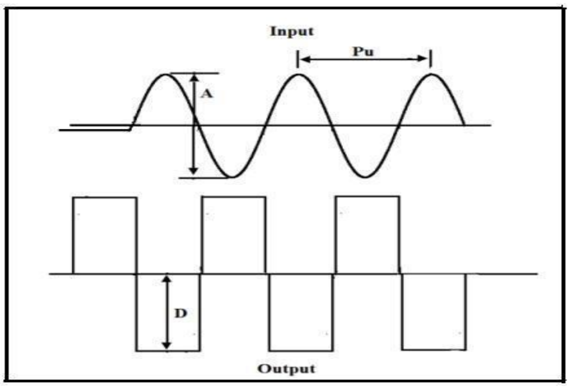

Fig. (c) The Relay method

Table (1) shows values for tuning parameters:

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Controller type	Kp	Ki	Kd
P	0.5Ku	-	-
PI	0.4Ku	0.48Ku/Pu	0
PID	0.6Ku	1.2Ku/Pu	0.075KuPu

Where $Ku=4D/A\pi$

D is the relay output, A and Pu are the amplitude and period of oscillation of the process variable respectively.

B. PEAK TRACING

In a virtual lab, identifying the peak or crest is very easy. But the signal from the transmitter can be noisy where the signal i.e. process variable crosses the set-point multiple times. Therefore, there is a need to consider a noise band. Fig (d) shows signal in a noisy world.

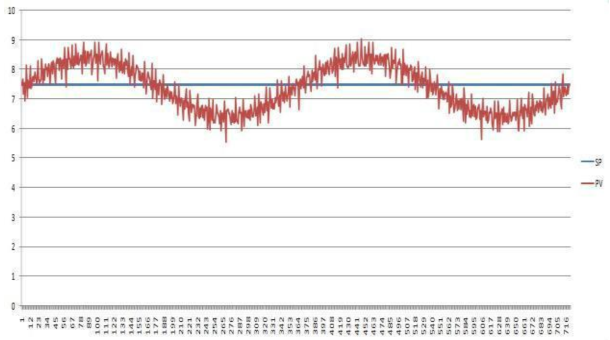


Fig. (d) Noisy signal

In order to find the peak, a method called "Peak Tracing" is used. In this method, whenever a peak greater than the previous peak is found, it is considered as a possible peak. The peak and period of the signal can be found using the method shown in fig. (e).

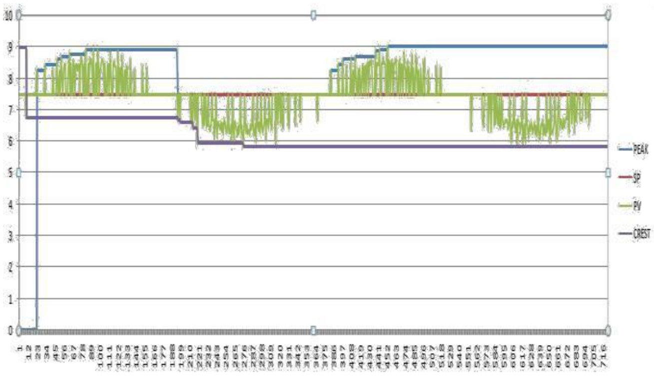
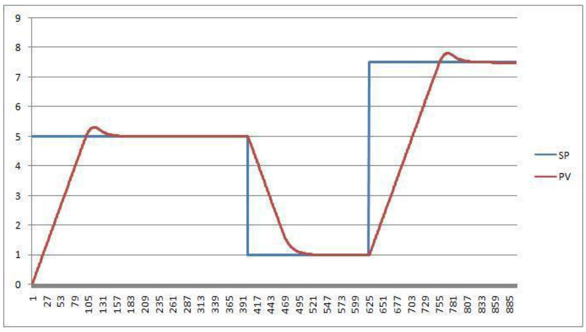


Fig. (e) Peak Tracing

IV. RESULT



The graph above shows the behaviour of process variable for different set points when it is tuned at required set points. As shown the process variable follows the set point with less error. Also there is no cycling of process variable hence the transient response is stable and settling time is small to meet desired specifications.

V. CONCLUSION

In this paper, the PID controller is auto-tuned during the relay experiment to give specified performance specification. Peaks are identified from noisy signals using peak tracing method algorithm and thus the amplitude and peak are found. These values are used to get tuning parameters.

VI. ACKNOWLEDGEMENT

We express our deep gratitude to Prof. H.P. Chaudhari, Prof. S.C.Rajgade, Prof. D. R. Shende, Mr.Yogesh Gothe, Mr. Pratik Mule and Mr.Tejal Deshmukh for their timely and valuable guidance. We also like to thank staff for their continuous support.

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