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The Optimum Controller Design for a Level Process

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ABSTRACT The level control processes are widely used in process many industries like power plant's drum leve control, oil industry's distillation level control and chemical plants. The control of level is major role in such the industries. Because of the level control of the plant decides desired production level both on quality and quantity basis. It can be achieved through proper control of level process. In a process control plant, if the level control will not properly, it will leads the plant to hazard action through overflow or low level. In the article, the level control of a cylindrical tank is performed. Here the system's liquid level is controlled by Proportional (P), Integral (I) and derivative (PID) modes with various tuning techniques like -N, Damped Oscillation Method, Tyreus Luyben Method and Cohen-Coon Method. Then the designed controllers are validated by comparing its performance criteria's like Integral square error (ISE), Integral of absolute error (IAE), Integral of time absolute error (ITAE) and Integral of time square error (ITSE) in MATLAB environment.

KEYWORDS: Level process, PID, Tuning Method in Z-N, Damped Oscillation Method, Tyreus Luyben Method, Cohen-Coon Method, Integral of square error (ISE), Integral of absolute error (IAE), Integral of time absolute error (ITAE) and Integral of time square error (ITSE).

I.INTRODUCTION

Level process is extensively used in process industries, food process industries and wastewater treatment industries. One of the industrial level process of waste water treatment is a process mainly comprises of cleaning, purification of water or recycling with using PH treatment. This clean water is then discharged or recycled for re–use. In general, these water treatment processes had different phase like level process, filtration, flocculation and several other processes. In purification of level process of sewage water passes through different purification chamber such as desalting, mixing...etc. The level process for the smooth monitoring of liquid level and then high efficiency to no disturbance of error and no overflow process. The level as monitoring our products in powder tank of suspended solid at bottom of the sedimentation reservoir, alkaline lime tank etc. In many of the powder tanks they are used to electromechanical level measuring system. In many of the industries digital display panel meters are used in control rooms to monitor the information transmitted from factory tanks. Its operation can be remotely observing the changes in range and quantity of flow in water level to be controlled. These are mainly too many of industries controller design with processes execution. The details description of design A Comparison of Proportional-Integral-Derivative (PID) Controller tuning methods for three tank level process [1].The carried out experiment in model based controller design for a level process [2].To measure the best response to comparison of PID controller tuning methods [3].To design and implementation of PID controller to based conical tank level control process [4]. Explain the modelling and simulation of non-linear tank in real time process of level control system [5].To describe the study and analysis of various tuning methods of PID Controller for AVR System [6].In designed model predictive controller to level process for PI controller design fuzzy and ANN tuning methods [7].So these are the various processes to execution of level process in modelling and then designing. In this paper to conducted by a level process in minimum error, quick or certain time of process and then high efficiency to make on the controller to design on level process.

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II.PROCESS SETUP

A.EXPERIMENT SETUP

The process control loop is consisting of mainly process, sensor and a controller. A sensor is sensing the same amount of current parameter values to get the controller input after signal conditioning is done performance. The controller also gets the set point from the user and it first generates error signal which set point minus feedback variable. The controller is the control mode of (such that ON/OFF or P, PI, PD and PID) computer as the controller these given by a FCE (final control element).

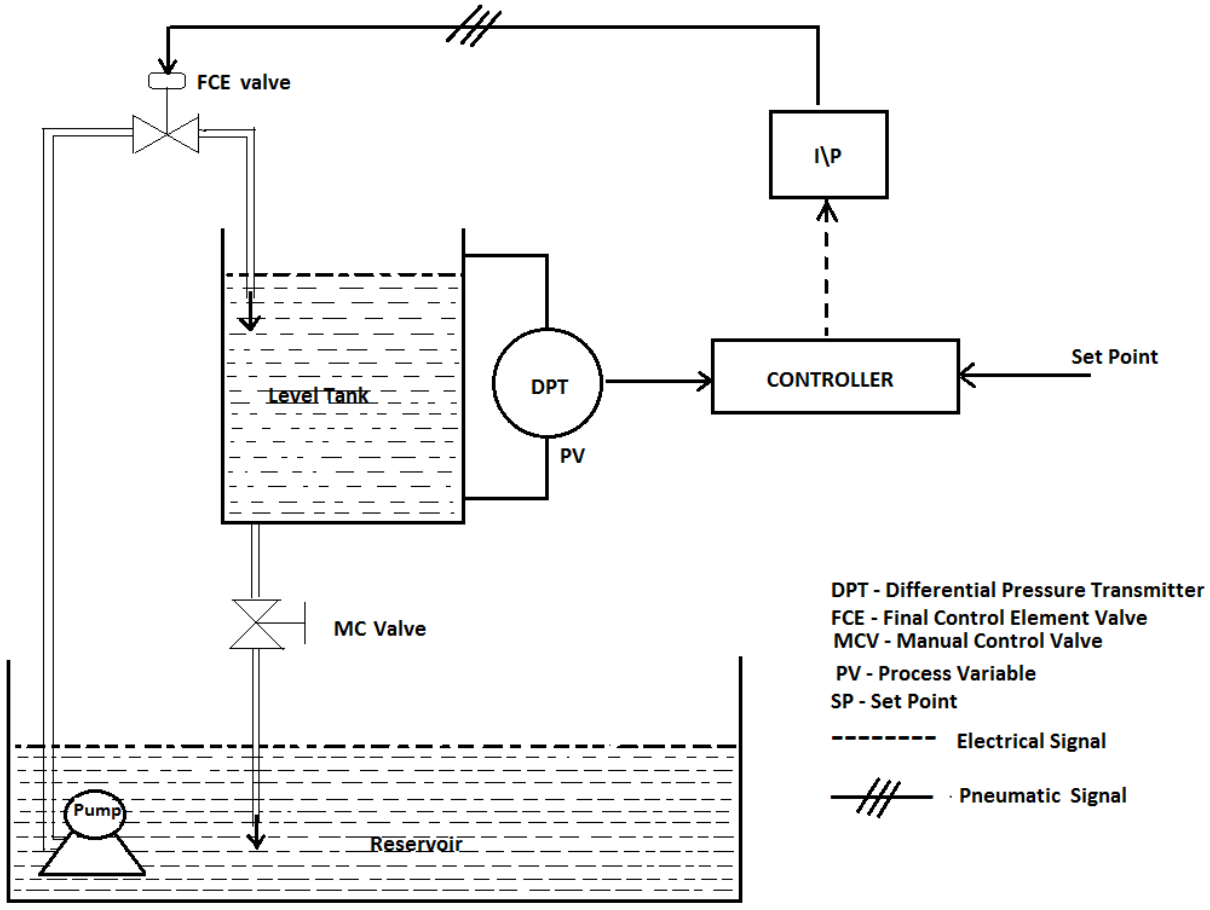

Figure II.A: Piping and Instruments to Implement the Circuit Diagram

In the case of computer which has all mode control action as software. The process of level tank is observed to the reservoir water with help of pump. The level sensor is fitted on transparent process controlled by adjusting water flow to the tank by a pneumatic control valve. In necessary piping and fitting are mounted in support how designed to stand on bench top. The control of process microcontroller, output indicator, power supply for level transmitter, switches….etc.

The reservoir water are filled with tank, the computer or microprocessor to involve pneumatic input signal are controlled by Final Control Element(FCE) valve and gets detect the set point with help of DPT. The operation of this process to start up the set up and close loop control model. In different controller used to (P, PI, PD, and PID) select and set to manual mode. The selection of controller to process characteristics and in all case of tuning of controller designed. The operation of this experiment is to start up to the set up and select the close loop control and then select

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the controller in (P, PI, PID) .Set the manual mode and adjust the output to that process value reaches of 50%. Switch the controller to auto mode and decrease the proportional band and apply the step change to set point of observe the process response.

Table II.A. Technical Details of Equipment used in Experiment Setup

S.No	Name of the Equipment	Specification
1.	Process tank	Transparent, acrylic
2.	Level transmitter	Type capacitance ,two wire, range 0-300mm, Output 4-20MA.
3.	Pump	Fractional horse power, type centrifugal
4.	Control valve	Type: pneumatic; size:1/4", input: 3-5psi
5.	I/P converter	Input4-20Ma, output 3-15 psig

III. SYSTEM IDENTIFICATION

The system identification of these level process is using to input&output technique of process reaction curve method is used. The process reaction curve method is one of the closed loop system of will respond in a desirable way only, if its controller is properly tuned .The process reaction curve method is some procedure to implement the system identification.

The first step is place the controller in manual mode and wait for the process variable (pv) to come to a study state value.the another step is cause a step chage in the out of X percent ,say 6 to 12%.The process variable (PV), will after a time ,begin to chage and if it is a typical loop, the process variable will approach some new values.

The process curve traced by the change is called the reaction curve.Above the level process to excecution of output to determine the tansfer fuction is,

$$\text{Transfer Function} = \frac{0.357}{S+0.233} e^{-0.150}$$

If transfer function,We can use with in MATLAB software to implement the find out in freqeuncy and gain. These are in values to the various tuning method is used to optimum of level process to predict the values.

IV.CONTROLLER DESIGN

PERFORMANCE OF VARIOUS TUNING METHOD

These are level process to use an three type tuning methods used,

IV.A.Ziegler-Nichols Method
IV.B.Tyreus-Luyben Method
IV.C.Cohen-Coon Method

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A. ZIEGLER - NICHOLS METHOD

These method is a closed loop tuning methodand in this case the controller remains in the loop as an active controller in automatic mode.In ziegler-nichols as trial and error based method on sustained oscillations of first proposed in 1942.To determine the critical gain (ku) and critical period(pu)are various ways, the proportional regulator is connected to system, the gain is gradually increased until an oscillation is obtained. In gain When this occurs the critical gain and the period oscillation is critical gain.

Table IV.A. closed loop ziegler-Nichols formulas

Controller	Kc	τI	τD
P	0.5Kcu	-	-
PI	0.45Kcu	Pu/1.2	-
PID	0.6Kcu	Pu/2	Pu/8

B. TYREUS-LUYBEN METHOD

Tyreus-luyben rules like the Ziegler-Nichols, they use ultimate gain Ku and ultimate period Pu. For only proposed in PI and PID controllers. In Ziegler-Nichols method this time consuming and forces the system to margin if in stability. This setting is based in ultimate gain and period is given table (2).

Table IV.B. Tyreus-luyben formula

Controller	Kc	τI	τD
PI	Kcu/3.2	2.2Pu	-
PID	Kcu/3.2	2.2Pu	Pu/6.3

C. COHEN –COON METHOD

Cohen and coon published their tuning method in 1953. This method is an open loop method, in which the control action is removed from the controller by placing it in manual mode and a transient is induced by a step change in the signal to the value. The Cohen-coon tuning rules work well on processes where the dead time is less than two time the length of the time constant. Cohen-coon provides one of few sets of tuning rules for PID controller should you ever need this. These relations were developed empirically to provide closed loop response with a ¼ decay ratio.

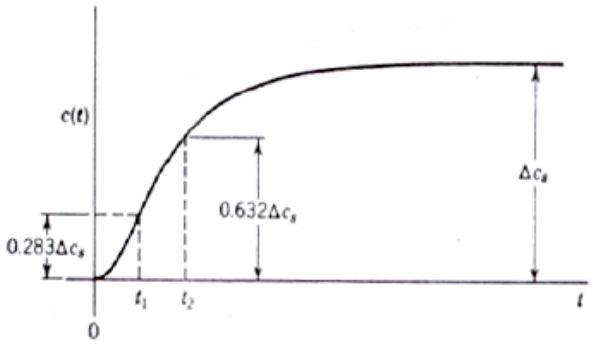

Figure IV.C: process reaction curve

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Where,

T = 1.5 (t2 --t1)
Tm = (t2 –tm)
C = plant output
t1 = time at which Δc = 0.283 Δcs
t2 = time at which Δc = 0.632 Δcs

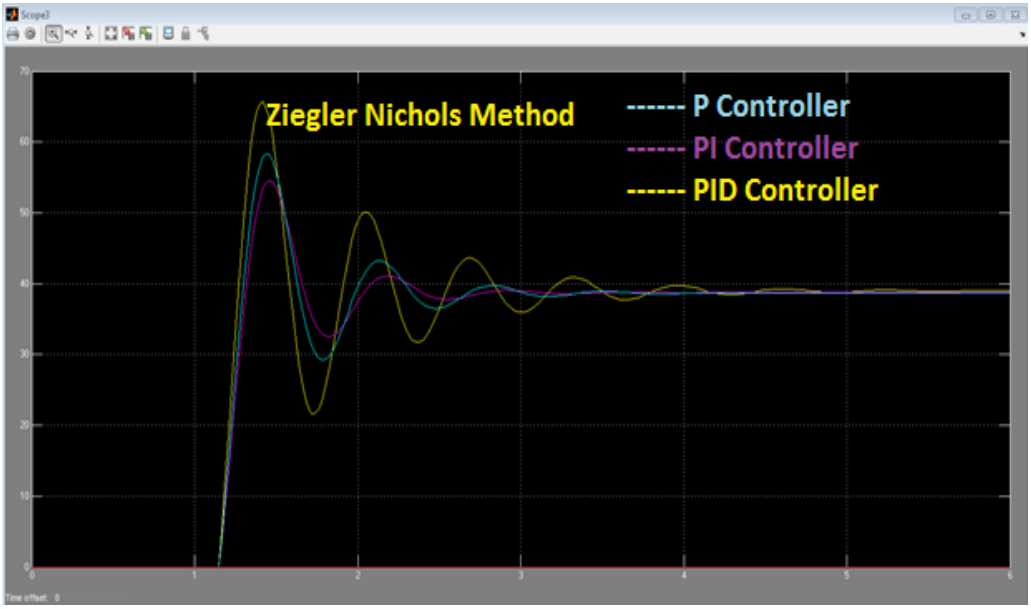
The Cohen coon method as typically used to determine the reaction curve on figure (C).The parameters which have to be determining for this method are K_m, τ_m and t_d.

Table IV.C cohen coon tuning formula

Controller Type	k_c	τ_I	τ_D
P	$\frac{1}{K_m}\frac{\tau_m}{d}(1+\frac{d}{3\tau_m})$	-	-
PI	$\frac{1}{K_m}\frac{\tau_m}{d}(\frac{9}{10}+\frac{d}{12\tau_m})$	$d\frac{30+3d_m/\tau_m}{9+20d_m/\tau_m}$	-
PD	$\frac{1}{K_m}\frac{\tau_m}{d}(\frac{5}{4}+\frac{d}{6\tau_m})$	-	$d\frac{6-2d/\tau_m}{22+3d/\tau_m}$
PID	$\frac{1}{K_m}\frac{\tau_m}{d}(\frac{4}{3}+\frac{d}{4\tau_m})$	$d\frac{32+6d/\tau_m}{13+8d/\tau_m}$	$d\frac{4}{11+2d/\tau_m}$

V.RESULT

Above discribe the three types tuning methods are used to implement the various of simulation performance are,



Figuer V.A: Z-N Tuning method

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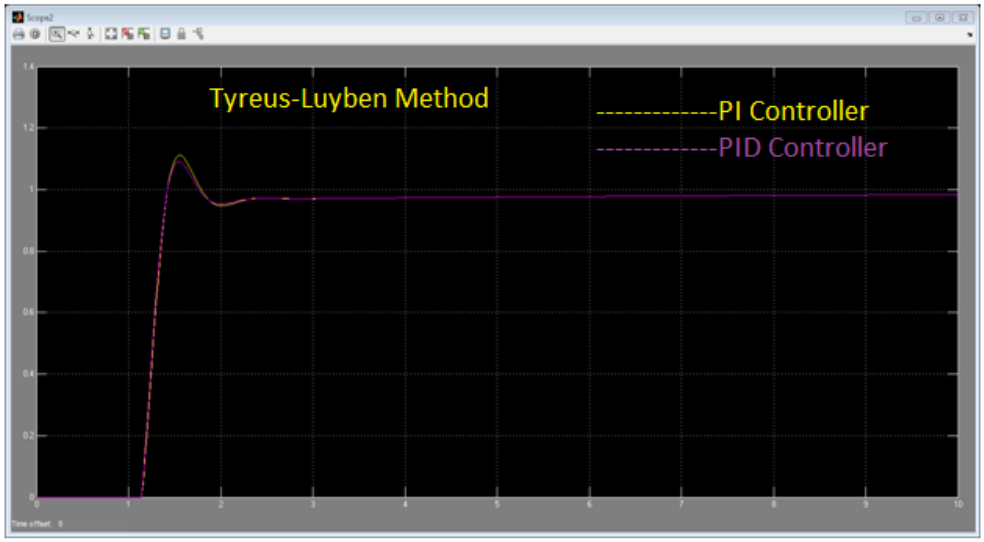

Figure V.B: Tyreus-Luyben Method

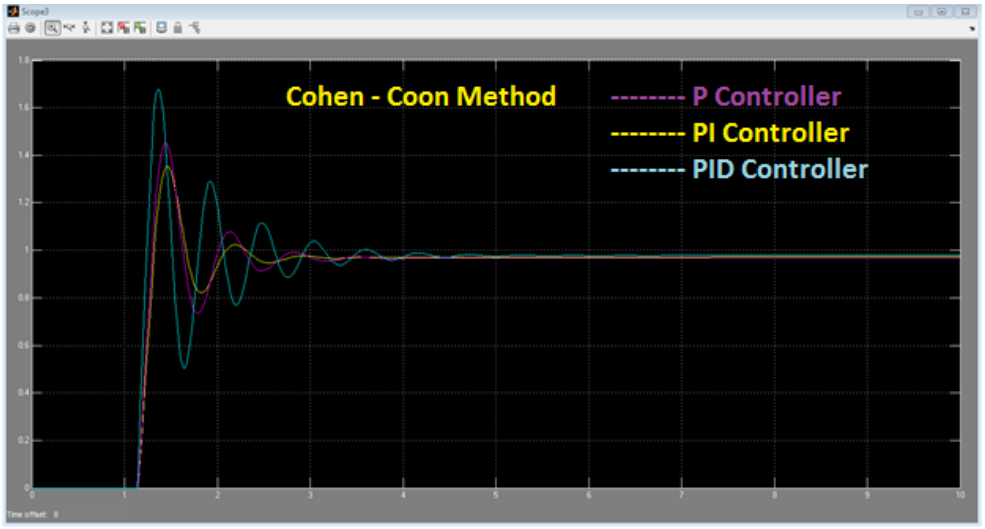

Figure V.C: Cohen - Coon Method

VI. CONTROLLER PERFORMANCE MEASUREMENT

Table VI.A Erorr values Comparesion

Z-N	ISE	ITAE	IAE
	501.9	81.4	29.62
COHEN-COON	479.2	73.52	27.76
TYREUS-LUYBEN	369.1	55.29	19.25

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VII.CONCLUSION

The controller design is most important one in process control industries. In the proposed article, the concept of controller design is carriedout on PID mode. It is performed with the help of differnet method of controller tunning like Zigular-Nichol, Tyreus-Luyben and Cohoon Coon. In the different techniques, it is proved that the Tyreus-luyben based controller design which gives better result. It is proven by comparing its performance indexes such as ISE, ITAE and IAE. Finally, the Tyreus-Luyben method based controller design gives the better result to the proposed process. Thus, the Tyreus-Luyben method based controller design is optimum for the proposed process,

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