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COMPARATIVE ANALYSIS OF PID CONTROLLER FOR A FLOW PROCESS

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Abstract: The article proposes an approach to tune the various controllers employed in flow process. The objective is to maintain the desired flow by means of a float in the rotameter. The process model is identified by step test. Various controller tuning methods like Z-N and IMC are applied to the obtained process model. The results are compared and the best among the two is validated and highlighted through time domain specification. Experimental results confirm that Internal Model Control (IMC) has better performance when compared to Ziegler Nichols method (z-n).

Keywords: PID controller, Ziegler-Nichols (Z-N), Internal Model Control (IMC), Flow Process.

I. INTRODUCTION

In many industries the flow control is of much importance. It is widely used in process industries where the flow of process proves to be intricate. The flow process can be carried out for three broad fronts- solid, liquid and gas. In this article we follow the principle that the flow rate of liquids is determined primarily by the pressure, which is the force exerted on the fluid. In order to carry out this process we employ various control techniques like Ziegler Nichols[1] and Internal Model Controller[3].

Our key objective is to maintain the desired flow rate in the pipe. One of the easily approachable flow meter that is orifice is used in the set up. Orifice restricts the flow and creates a differential pressure which is proportional to the square of the flow rate. The orifice is concentrically bored such that the hole lies exactly at the middle of the internal diameter. Initially a pressure difference is created in the orifice. And as a result of this, we measure the pressure created using a differential pressure transmitter which indirectly indicates the flow rate also. If the flow rate oscillates above or below the set point, control action is carried out. Ziegler and Nichols[1] proposed an idea which involved frequency response analysis. This tuning technique is a closed loop procedure. The Internal Model Control (IMC)[3] structure also provides a suitable framework for satisfying the objectives. IMC was introduced by Garcia and Morari but a similar concept has been used previously and independently by a number of other researchers.[5,6,7,8,9]

II. MATERIALS

A. EXPERIMENTAL SETUP

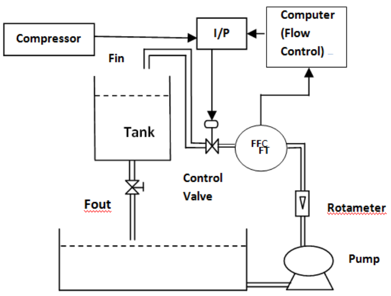

Fig 1. Experimental Setup

III. PROCESS IDENTIFICATION

The process is identified by the Step Test[2] method. This phenomenon was developed by Ziegler and Nichols[1] and is commonly known as "Process Reaction" or "Transient Response" method. The basic approach is to open the feedback loop, so that no control action occurs. Initially the process is set at manual mode and step test is performed by varying the inflow rate. The open loop step response is obtained and the transfer function for the Process Reaction method is framed.

A. Steps involved in generating a transfer function

A transfer function is basically a (linear) way of describing a relationship between an input & output. Transfer functions are a well-established convention for articulating the system response characteristics.

The controller is set at manual mode and waited till the process reaches the settling state. A primary step change is given in the flow and ensured that the process variable (PV) settles at a new value. The process gain is calculated as follows,

$$\text{Process gain (K)} = \frac{\text{Change in process value}}{\text{Change in manipulated value}}$$

The Process Variable response curve yields the maximum slope value. This value indicates the inflection point. A line tangential to the Process Variable response curve through the point of inflection is drawn. This line is extended so that it intersects the original level of the Process Variable and the time value is noted.

B. Measurement of dead time (θ)

θ = Dead time is the amount of time taken by the process variable to first respond after the change in input

C. MEASUREMENT OF TIME CONSTANT (τ)

τ= time difference between the dead time and Process variable reaching 63.2% of its total change. The value of the Process Variable at 63.2% (0.632) of its final value is taken as time constant

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D. General format of a transfer function

$$G(s) = \frac{K\, e^{-\theta s}}{\tau s+1}$$

E. Transfer function obtained

$$TF = 0.746e^{-2S} / 15S+1$$

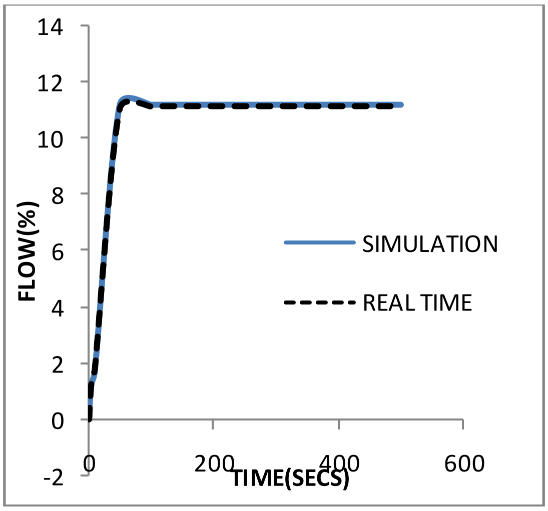

Fig. 2. Comparison of real time and simulation values in flow process

IV. CONTROLLER DESIGN

A. Ziegler nichols method

Using a graphical trial and error approach the designer can alter the design parameters to values that lead to an acceptable response and then verify the design by solving for the time response of the system.

Type of control	Gc(s)	Kc	Ti	Td
Proportional-Integral-Derivative (PID)	Kc(1+1/ TiS+Tds)	$0.6k_u$	$P_u/2$	$P_u/8$

Table 2. Tuning formula

B. Internal model control

Internal Model Control (IMC)[3] is a commonly used technique that provides a transparent mode for the design and tuning of various types of control. The IMC structure provides a practical tool to influence dynamic performance and robustness to modeling errors transparently in the design.

Type of control	Model	K_c	T_i	T_d
Proportional-Integral-Derivative(PID)	$\frac{K_e^{-\theta s}}{\tau s+1}$	$\frac{1}{K}\frac{\tau+\frac{\theta}{2}}{\tau_c+\frac{\theta}{2}}$	$\tau+\frac{\theta}{2}$	$\frac{\tau\theta}{2\tau+\theta}$

Table 3. Tuning formula

V. RESULTS AND DICUSSION

The graph (time vs. flow) is plotted for flow process. It clearly depicts the curves of two controllers (Z-N and IMC). The best among the two will be selected and will be highlighted.

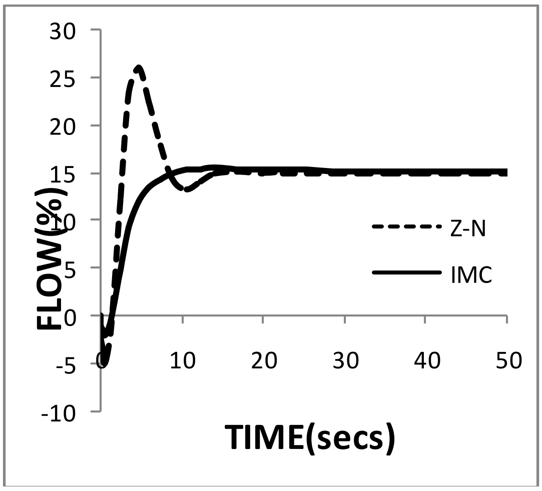

Fig. 3. Comparison of controllers in flow process

The graph (time vs. flow) was plotted for flow process. It clearly sights the curves of two controllers (Z-N and IMC). The comparison between two curves is done and the best one will be highlighted.

Controller	K_c	T_i	T_d
Ziegler-Nichols (Z-N)	12.87	2.795	0.698
Internal model control(IMC)	7.149	16	0.938

Table 4. Obtained controller parameters

Specification	ZN	IMC-PID
Rise time(seconds)	2.666	8.746
Overshoot	10.76	0
Settling time(seconds)	20	10.4

Table 5. Time domain specifications

VI. CONCLUSION

As the IMC approach is based on pole zero cancellation, methods which comprise IMC design principles result in a good set point responses. Therefore from the time domain characteristics such as rise time, minimum settling time and zero overshoot we arrive at a conclusion that IMC proves to be an improved choice than Z-N method.

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REFERENCES

[1]. G.Ziegler and Nicholas,"Optimum Settings for Automatic Controllers", Trans.Asme, 62,1942,pp.759-768.
[2]. M. Morari and E.Zafiriou, Robust Process Control, Englewood cliffs, prentice-Hall, 1989.
[3]. Donald R. Coughanowar, Process System Analysis and Control, Second Edition, Tata McGraw Hill, 1991.+
[4]. B.Wayne Bequette, Process Control: Modelling, Design and Simulation, Prentice Hall (2003) of India.
[5]. J.Prakash, K.Srinivasan,"Design of Non Linear PID Controller and Non Linear Model Predictive Controller for a Continuous stirred tank Reactor", ISA Transactions 48(2009)273_282.
[6]. S.M. Girirajkumar, K.Ramkumar, Bodlarakesh, Sanjay Sarma O.V. and Deepak Jayaraj,"Real Time Interfacing of a Transducer with a Non-Linear Process Using Simulated Annealing", Sensors and Transducers Journal, Vol.121,Issue 10, October 2010, Pp.:29-4.1
[7]. V.R.Ravi, T.Thyagarajan,"Application of Adaptive Control Technique to interfacing Non Linear systems" Electronics Computer Technology(ICECT),2011 3rd International Conference on 8-10 April 2011, Pp.:386-392.
[8]. P.Aravind, M.Valluvan and M.Saranya,"Simulation Based Modelling and Implementation of Adaptive Control Technique for Nonlinear Process Tank" International Journal for Computer Applications, Entitled Volume68,No.16,April 2013.