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Performance Scrutiny of Flow Process Using Diverse Controllers

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Abstract: *Flow measurement is an important controlling parameter in industries. This paper aims to shed some light on PID controller and comparison of various tuning parameters is determined. Tuning is done by computer simulation.Simulink is an interactive tool for modeling ,simulating and analyzing dynamic,multi-domain systems.PID algorithm has sufficient flexibility to yield excellent results in wide variety of applications. It offers high accuracy and better performance. Most modern PID controllers in industry are implemented in programmable logic controllers. The efficiency of the various PID controllers are determined using ISE,ITAE,MSE.This paper drafts the comparison of various tuning parameters to obtain better optimal response.IMC(Internal model control) ,ZN-PID(Ziegler- Nichols),T-L(Tyreus- Luyben) are the tuning methods used in the model. This paper results that IMC method has better performance than other methods.*

Keywords: *PID controller, IMC, Z-N, T-L, flow process.*

1. Introduction

In Many industrial processes, controlling the outlet flow of liquid is the vital role for obtaining Optimum result in the plant. Conventional controller has been developed for controlling the outlet flow of the liquid in the plant. Even though these controllers have three tuning parameters, but determining the reverse parameter in these controller is difficult, so that we are going for many sophisticated controller for controlling purpose. To achieve an optimum result the dynamic model, desired closed loop of the system and the tuning parameters are considered and they are taken into account. The controller such as ZN-PID, T-L, and IMC are taken to achieve these criteria. IMC has better performance than other controller; the filter parameters in IMC are considered and are used to tune the model of the given system to get desired output. IMC-PID gives long settling time because of the filter parameter, by choosing higher filter parameter the performance of the system will give better performance. Disturbance rejection is the another major factor in IMC than set point tracking,

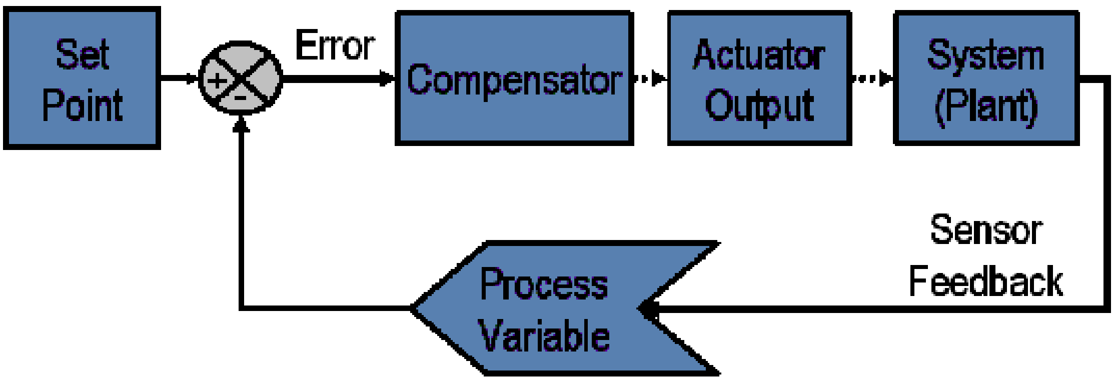

Fig1. *Block Diagram of Closed Loop System*

Nowadays conventional controller is being used in many process industries. The PID control algorithm is almost used in all loops in the process plant and in industries. But the difficulties in tuning PID algorithm in real time process are overcome from many advanced control algorithms and approaches. Different PID techniques like TL-PID, IMC-PID are used nowadays for tuning the real time process. Since the difficulties in PID are conquer by IMC-PID and it gives better performance than all other controller. IMC-PID is the most sophisticated controller for flow process.

In a typical control system, process variable is the system parameter that needs to be controlled the flow rate .A sensor is used to measure process variable and provide feedback to the control system.

The set point is the desired value for the process variable. The difference between the process variable and the set point is used by control system algorithm(compensator) to determine the desired actuator output to drive the system.In many cases the actuator output is not only the signal that has an effect on the system. Closed loop system is able to regulate itself in presence of disturbance or variations in its own characteristics. Hence closed loop system has an distinct advantage over an open loop system

2. Flow Process Station

The process setup consists of supply water tank fitted with pump for water circulation. The water circulation rate can be measured by rota meter. The flow sensor is fitted on the orifice meter. The water flow to the process is controlled by pneumatic control valve. These units along with necessary piping and fitting are mounted in support housing design to stand on bench top. This setup is to be operated along with control cubicle. The control cubicle houses process indicator, microprocessor, output indicator, power supply for flow transmitter, control switches etc.,The control cubicle is connected to process setup by electrical connectors. The process parameter is controlled through computer or microprocessor by manipulating water flow to the process.

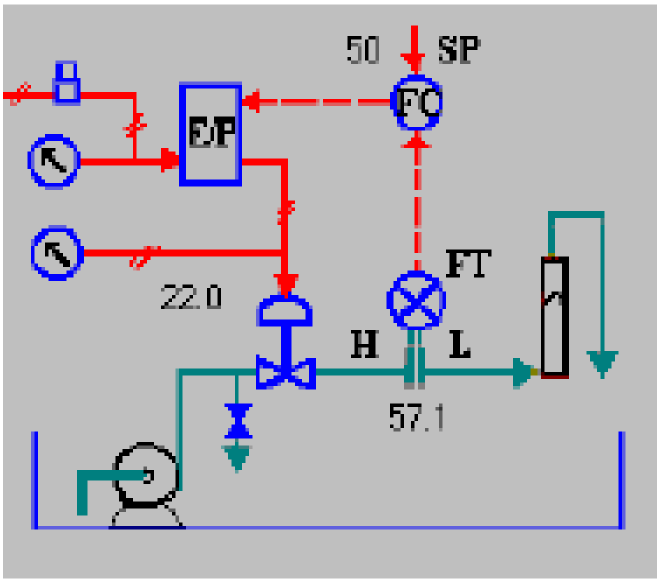

Fig2. *Flow Process Station*

3. Process Station

System identification of the process is done by means step response method. The open loop step response of the flow process is determined and the transfer functions are obtained by process reaction curve method. The first order plus dead time process is given by (FOPDT)

$$G(s) = \frac{Ke^{-\tau ds}}{\tau s + 1}$$

4. Controller Tuning Methods

4.1. Ziegler- Nicholas Method

The Ziegler-Nichols tuning method was developed by John G.Ziegler and Nathaniel B. Nicholas. It is a trial and error method, in which sustained oscillations are obtained, by varying the ultimate gain value, by keeping integral and derivative values to zero. This method does not require process model.

Table1. *Controller Parameters for ZN*

Controller	K_c	τ_i	τ_d
P	$0.5K_u$		
PI	$0.45K_u$	$P_u/_{1.2}$	
PID	$0.6K_u$	$P_u/_2$	$P_u/_8$

4.2. Tyreus- Luyben Method

Tyreus-Luyben method is similar to Ziegler -Nichols method but the final controller settings are different. This method is only used for PI and PID controls. These methods are based on ultimate period and ultimate gain. Tyreus-Luyben method gives zero overshoot with high settling time.

Table2. *Controller Parameter for TL*

Controller	K_c	τ_i	τ_d
PI	$K_u/3.2$	2.2 P..	-
PID	$K_u/3.2$	2.2 P..	$P_u/3.2$

4.3. Internal Model Control

IMC was developed by Morari. It is a model based controller, in which model transfer function is determined.

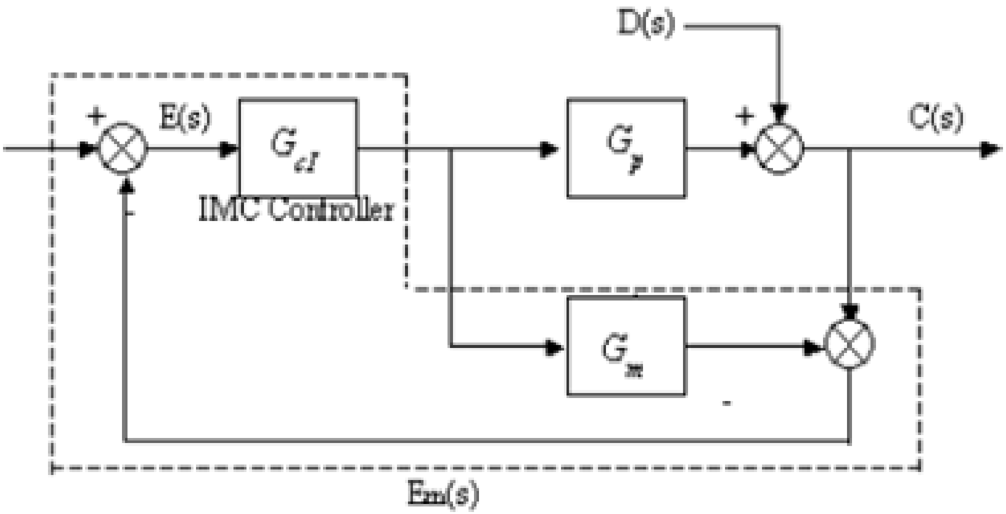

Fig2. *Internal Model Structure*

In this G_p is the transfer function of the process, G_m is the transfer function model. G_{cl} is the IMC controller transfer function. The structures of IMC are rearranged to get feedback loop, so that it has better disturbance rejection in the input.

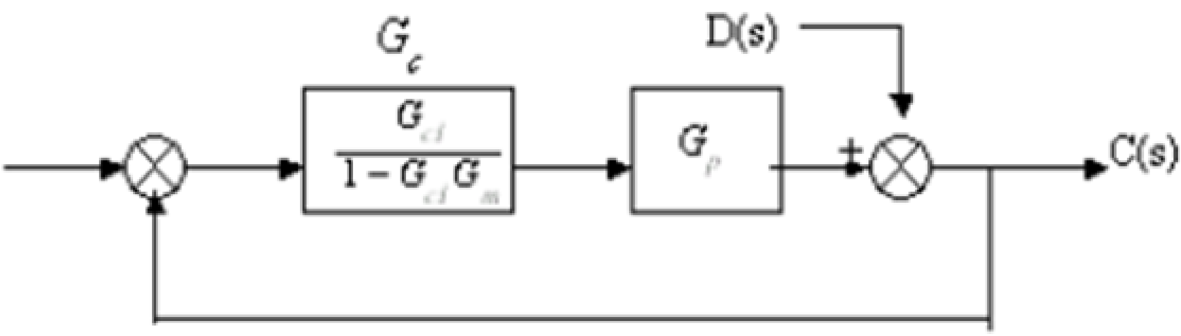

Figure 2. *Equivalent Internal Model Structure*

The filter parameters in the IMC are used to tune to get obtained optimum result in the output. The dead time in the process are estimated to pade approximation.

Table3. *Controller Parameter for IMC*

Controller	K_c	τ_i	τ_D	τ_D	*Recommended* $\frac{\lambda}{d}$
PID	$\frac{2\tau + d}{2(\lambda + d)}$	$\tau + \frac{d}{2}$	$\frac{\lambda d}{2\tau + d}$	$\frac{\lambda d}{2(\lambda + d)}$	>0.25
PI	$\frac{\tau}{\lambda}$	τ	-	-	>1.7
Improved PI	$\frac{2\tau + d}{2\lambda}$	$\tau + \frac{d}{2}$	-	-	>1.7

5. Simulation Result

The IMC based controller was designed flow process. The performance of the controller was compared with various conventional controllers and result was tabulated. The performance of the controller was compared Time domain specification and Performance indices. It is evident that IMC gives better performance in terms of performance indices and time domain specification.

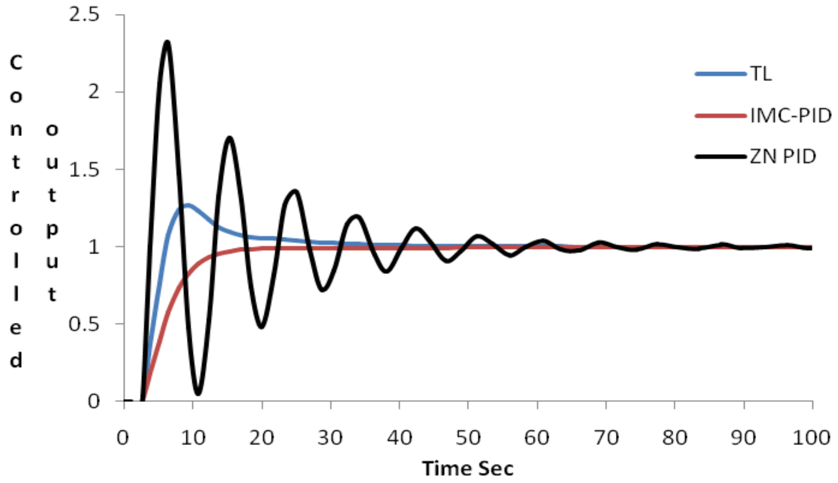

Fig3. *Process Output*

Table4. *Time domain specifications*

SPECIFICATIONS	*Z-N*	*T-L*	*IMC*
Rise time	1.95	2.75	1.45
Settling time	80	55	25
Overshoot	2.29	1.25	0

Table 5: *Performance Specifications*

CONTROLLERS	*ISE*	*ITAE*	*MSE*
Z-N		2.0937	20.41
T-L		438.01	0.6865
IMC		228.225	0.4049

6. Conclusion

Hence the IMC approach is based on zero pole cancellation it exhibits good set point response. Therefore we arrived at a conclusion that IMC method has better performance than other methods. From the time domain specifications it is noted that IMC has minimum rise time, minimum settling time and zero overshoot.

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