PERFORMANCE EVALUATION OF DIVERSE CONTROLLERS FOR FLOW PROCESS

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ABSTRACT:This paper deals with the development of different control techniques for flow control process. The different controllers includes Proportional Integral Derivative controller (PID), Model Predictive Controller (MPC) and Internal Model Controller (IMC) which are simulated inMatlabenvironment. The three parameters of PID controller must be tuned to the process to obtain a satisfactory closed loop process performance. Here the performance analysis of the conventional PID controller ,Internal model controller and model predictive controller has been done by the use of Matlab and Simulink. The comparison of various time domain parameters is done to prove that the Model predictive controller has small overshoot and fast response as compared to PID controller and IMC based PID controller. The performance comparison demonstrates a good association between PID,MPC and IMC controller .

Index terms:PID controller,IMC controller,MPC controller ,tuning methods,matlab.

I. INTRODUCTION

In many industrial plants, measuring the flow of liquids is an important and necessary thing. In recent years, flow control has become a highly multi-disciplinary research activity on all sides of theoretical, computational and experimental fluid dynamics[2]. In recent years ,many new types of controllers have been evolved. PID and MPC are two control algorithms widely used in industrial applications[6].Although, a PID controllerhas only three adjustable parameters, finding appropriate settings is not easy, resulting inmany controllers being poorly tuned and time consuming plant tests often being indispensableto obtain process parameters for improved and show the best result among controller settings[5].There are several approaches for controller tuning, where ZN-PID and IMC-PID tuning methods are so popular.The problems of PID are overcomed by the most advanced controller named as model predictive controller[1].In this section we are going to compare the performance of various controller which are mentioned above them.

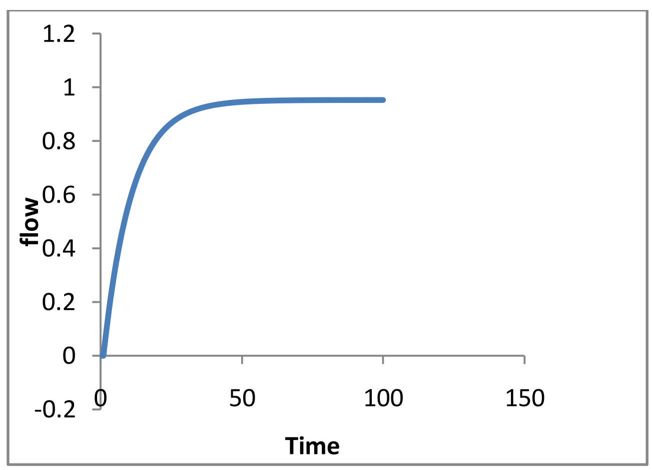

Figure 1Process indentification

This process is identified as the first order delay flow process.

The transfer function for such a system by a given by a equation

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

- From the process reaction curve the transfer function was obtained.
- Transfer function for this current flow process is:

$$Gp(s) = \frac{0.952e^{-s}}{10s+1}$$

II. PID CONTROLLER:

PID control is simple inprinciple, easy to tune ,robustness and successful realistic application, which is still widely used in industrial process control. The PID controller is an fundamental part of the control loop in the process industry[4] .Even though many advanced control modus operandi are based on a PID control algorithm, the conventional PID control algorithm cannot achieve ideal control effect in any practical production process with nonlinear and time varying uncertainty[3]. Advanced control methods can illustrate drastically improved performance but PID control technique can suffice for many industrial control loops.

III. CONTROLLER DESIGN:

Many methods are there to design a perfect PID such as Ziegler Nichols(ZN)tuning methodand Internal model controller. Here the parameters of PID are determined and tuned so as to obtain a exact steady state response for a step input[8]. Tuning rules work quite well when you have a analog controller, a system that is linear, monotonic and slow and response that is dominated by a single pole exponential lag.

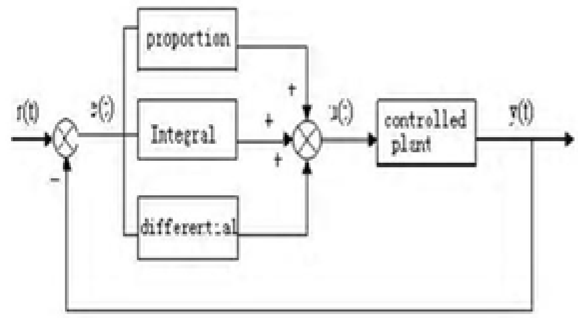

Figure 1: The analog PID Controller

IV. ZN tuning:-

ZN tuning rule is a basis for a coming new generation of PID technology." superior performance and easy to use". It is a algorithmic PID tuning rule that produce good PID gain parameters such as controller path gain(Kp),controllers integral time constant (Ti),the controllers derivative time constant(Td)[4]. Here two measured feedback loop parameters derived from measurements such as the period Pu of the oscillation frequency at the stability limit and gain margin Ku for loop stability[8]. From the bode plot , frequency is noted at 180^0 . In nyquist diagram the gain k_u was determined with the help of the frequency value.With the ku value pu was calculated from the equation [3]:

$$P_u = \frac{2\pi}{Wc_0}$$

Thus from this two values ku and pu ,parameters like proportional gain,integral time and derivative time constant was found by Ziegler Nichols table and substituted in the PID controller block.

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CONTROLLER	k_c	τ_{int}	τ_{der}
P	$\frac{KU}{2}$		
PI	$\frac{KU}{2.2}$	$\frac{PU}{1.2}$	
PID	$\frac{KU}{1.7}$	$\frac{PU}{2}$	$\frac{PU}{8}$

Table 1 Ziegler Nichols tuning table based on ultimate gain(ku)and ultimate period(pu)

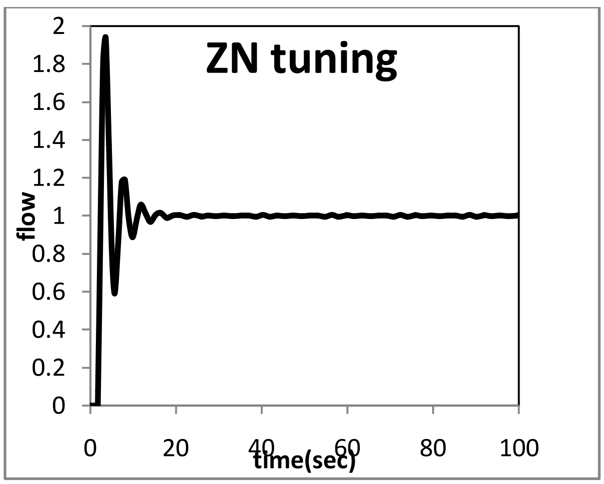

Figure 2:Graph for Z-N tuning

V. IMC based PID controller:-

Internal Model Control (IMC) is a commonly used technique that provides a transparent mode for the design and tuning of various types of control. The ability of proportional-integral (PI) and proportional-integral-derivative (PID) controllers to meet most of the control objectives has led to their widespread acceptance in the control industry[3]. The Internal Model Control (IMC)-based approach for controller design is one of them using IMC and its equivalent IMCbased PID to be used in control applications in industries[4]. It is because, for an actual process in industries PID controller algorithm is simple and robust to handle the model inaccuracies and hence using IMC-PID tuning method a clear trade-off between closed-loop performance and robustness to model inaccuracies is achieved with a single tuning parameter

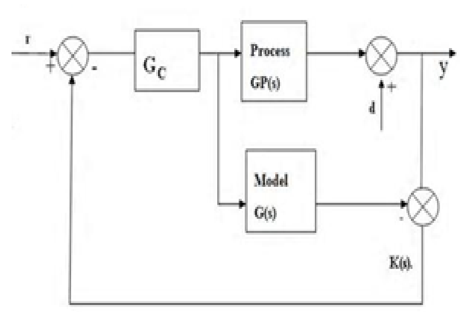

Fig. 1. IMC block diagram

The IMC structure can be rearranged to form a standard feedback control system that can easily handle open loop unstable system as not the case with IMC. This modification of the IMC design procedure is developed to improve the input disturbance rejection[3]. The IMC based PID structure which uses a standard feedback structure uses the process model in a hidden manner i.e. PID tuning constraints are frequently adjusted based on the transfer function model but it is not always clear how the process model affects the tuning result. In the IMC controller Qc(s) is directly based on the good part of the process[5] . Also the IMC generally results in only one tuning parameter, the close loop time constant (filter tuning factor). The IMC based PID tuning parameters are then the function of this τ(time constant). The choice of the closed loop time constant is directly related to the robustness (sensitivity to the modular of the closed loop system)[1]. Also, for open loop unstable processes it is necessary to implement the IMC strategy in standard feedback form, because the IMC suffers from internal stability problems. Though the IMC based PID controller will not give the same performance when there are process time delays because the IMC based PID procedures uses an approximation for the dead time[2]. Suppose the process has no time delays and the inputs do not hit a constraint then the IMC based PID controller give the same performance as does the IMC.

Tuning formulas for IMC

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kp	Ti	Td
$\frac{1}{K}\left(\frac{2\tau/\theta+1}{2\tau c/\theta+1}\right)$	$\theta/2+\tau$	$\frac{\tau}{2(\frac{\tau}{\theta})+1}$

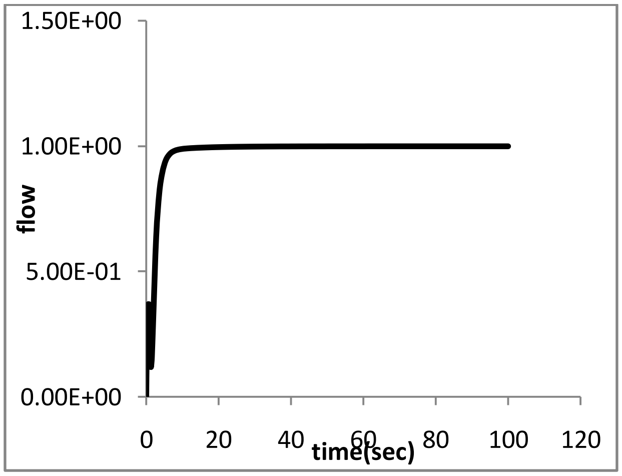


Figure 3 Graph for IMC based PID

VI. MODEL PREDICTIVE CONTROLLER

The most sophisticated form of advanced process control.It is a model based approach. Model predictive controllers rely on dynamic models of the system,a linear empirical models obtained by system identification [7].simple systems with dynamic characteristics that are difficult for PID controllers include large time delays and high-order dynamic can very well be handled with MPC .it handle difficult to control problems such as time delay,non minimum phase,non linearity,open loop instability,constraints and combination thereof[6].Also ,it will handle interactions of a multivariable nature.second ,despite its complexity,implementation of MPC is fairly straight forward because there are good quality robust packages available[6].

Most uses the current plant measurement ,the current dynamic state ,the MPC models,and the process variable targets and limits to calculate future changes in variables[7].These modifications are premeditated to hold the dependent variable. The MPC typically sends out only the first change in each independent variable to be employed, and replicates the calculation when the next change is required[9].This method is an advanced method of process in control industries in chemical plants and oil refineries.In recent years it has also been used in power systems balancing models.The main advantage of MPC is the reality that it allows the present time slot to be optimized,while keeping future time-horizon,but only implementing the existing time slot..MPC has the capability to predict future events and take control actions accordingly[10].It is a digital control.

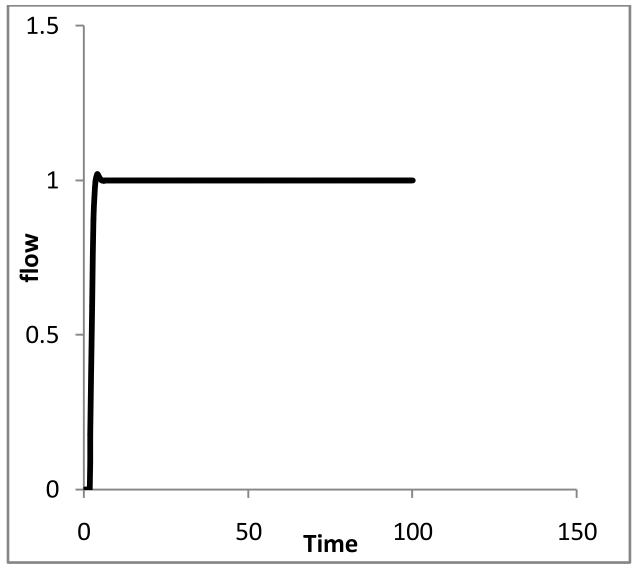
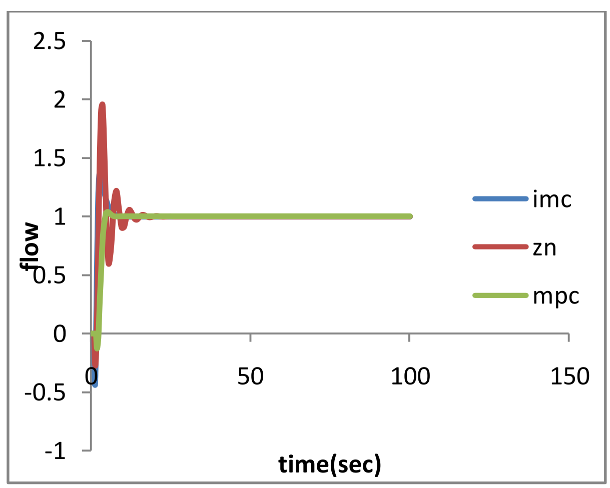


Figure 4 Graph for MPC

VII. RESULTS AND COMPARISON



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Thus the controllers like PID,IMC and MPC were compared and shown in a single graph. From this it is observed that MPC settles first compared to other two controllers.

VIII. CONCLUSION

This paper presents results obtained in the set of simulations for FODT processes when controlled with PID controller,IMC and MPC controller. The analysis clearly explains that set-point in PID control is far from constrainwhereas IMC control is better than PID. compare to other two controls ,MPC set-point is closer to constraint .In this paper it was proved that MPC tries to bring the process as close as possible to constraints without infringing them. These simulation results are useful to do the required modifications incontrol system industry for optimal control.

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