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Implementation of PID Controller for Level Process Using Significant Tuning Techniques

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Abstract

In this paper, we are going to maintain the level of the tank in the industries for a real time application process. Many industrial applications such as maintaining the level of the boiler, maintaining the level of the tank etc are used to analyse the level of the tank. Therefore, Level of the tank plays a crucial role in the process industries. By using the PID controller, we can control the level of the tank by giving the set point in the controller. Many types of controllers available to maintain the level of the tank. Among those controllers, we have to select the best controller suitable for our real time application process by analysing the time domain specifications. The different controller set point can be evaluated and the simulation results can be given below.

Keywords: Level process, Control system, Process control, PID controller, IMC, GA, Stability analysis, Servo response

1. Introduction

In chemical and power plant industries, tank level should be maintained properly. If in case, the level of the tank can be exceeds above or below, many hazardous and unwanted happenings can be done in the industrial. It may leads to affect the beneficial growth of the industries. It may also affect the people who works in the industries. by using the controllers, the tank level should be maintained. The user or the operator should set point over the controller. If the level of the tank exceeds above, the flow of liquid in to the tank should be

reduced or stopped. If the level of the tank exceeds below the set point range, the flow of liquid should be increased. The set point can be varied by the operation in the controller.

PID controllers can be done by using three parameters namely proportional gain(Kp), integral gain(Ki), derivative gain(Kd). PID controller parameters should be determined by using the single input single output system (SISO). These level processes can be done by using the interacting tank of a heat exchanger process. Proportional gain can be used in the controller to reduce the overshoot value in the process. Further, these proportional gain values can be varied by changing the values. Integral gain are the one where it can be used to eliminate the offset value. We can set the integral value according to the efficiency of the process. Derivative gain can be used to eliminate the oscillations produced in the system. PID controllers can be used to control the process and it can be used to achieve the desired output in the process.

PID controllers can play a crucial role over the process. Considering the controllers such as IMC,GA etc.., are used to predict the stability of the process by analysing the time domain specifications. Controllers can make the time domain specifications over a certain range and comparing all these controllers, we can justify the suitable controllers for the process. Time domain specifications such as rise time, peak time, peak overshoot, and settling time can be predicted through the process. The process can be done either by using two methods. One is a real time process, where the values can be changed by interfacing the plant with the computer. The other one is the simulation process, where software is available for the simulation of the process.

The performance of the experiment can be determined by analysing the controller values. Controllers can be used to achieve the output in a desired manner. In a real time applications, many controllers can be used for controlling the process parameters such as level, flow, temperature and pressure. Set point and a bias value can be used for the controlling of the parameters using a controller. Process can be done by varying the controller values according to the output of the process. Many industrial application processes can be done by using the controllers. Among those controllers, we have to select the suitable controller for the process.

2. Experimental Setup

The experimental setup of this process may consist of linear tank, flow reservoir, I to P converter, water pump and a level transmitter. These experimental setup can be interfaced with the personal computer. These personal computer are used to set the set point and bias values. The block diagram of this process can be given below.

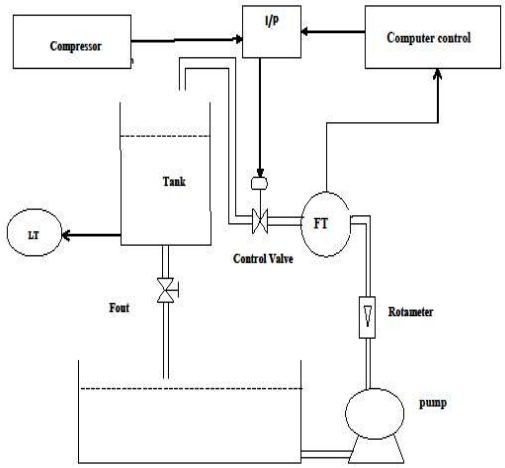

Figure 1. Schematic Diagram

In the above block diagram, the transparent cylindrical tank is used so that the level of the tank can be easily visualised by the person. The tank level can be predicted with the naked eyes. Level transmitter are used to analyse the level of the tank. It can be worked by the output of 4-20mA values. The electronic range of this level transmitter can be in the range of 0-90cm. the pump that are used to pressurise the water to the tank is a centrifugal pump with 0.5HP. The control valve that can be used are pneumatic actuated valve. The valve can have the input of 3-15psi. The pressure can be used to control the change in the control valve. The type that are used are air to close valve. The rotameter can be used for the flow of liquid to the tank are in the range of 10-100 LPH. I/P converter can be used to convert the current input signal to the pressurised output form. The input of the I/P converter is in the range of 4-20mA and the output of the I/P converter is in the range of 3-15 psi. pressure gauge can be used to measure the level of the pressue in the process and hence the range of the pressure gauge are 0-30psi.

3. Step test method

Step response are the one where it can be used for the system identification process. many number of graphical methods are available for the literature survey and it can be effectively

used for the real time application process in order to obtain the model of the system. inlet valve and the outlet valve are present in the process. initially, inlet valve should be fully opened and outlet valve should be partially opened. by varying the inflow rate, the open loop step response are obtained. experimental results can be obtained in terms of time and height of the system. The model in the process can be obtained either by Process Reaction Curve (PRC) method or by sunderasen kumaraswamy (SK) method. if there is any change in the step function, the process reaction curve method produces a response. response parameters such as dead time, the time taken for the response to change, and the ultimate value that the response reaches at steady state can be varied only when there is a change in step response values. similarly sunderasen kumaraswamy method is also used to produce a model from the obtained response. According to the structure of the curves, the FOPTD model can be represented as given below.

$$\mathbf{G(S)=\frac{Kpe^{-td(s)}}{ts+1}}$$

where k is the process gain and t is the first order time constant and td is the time delay.

the predicted values are to be evaluated with real time results and it can represented by using a graphical methods. the model that are obtaines from the SK method can be effectively suitable for the real time application process. from the response of real time system, the constants can be determined by using the SK method and we analyse the FOPTD model for the real time linear process are

Transfer function for flow process: $\mathbf{\frac{1.25e^{-79s}}{167.5s+1}}$

4. Design of PID Controller

PID controllers can be used to control the process by varying the tuning parameters. The gain values can be changed so that the process can control the reaction according to their applications in order to achieve the desired output.

5. Tuning Techniques

There are many tuning techniques that are used to control the process by varying the gain values. Her are some of the examples of tuning techniques are Zieger Nicholas, cohen conn,

IMC controller, genetic algorithm(GA), PSO etc.., in this paper, we discuss about two tuning techniques namely IMC controller and GA techniques.

6. Internal Model Control (IMC) Controller:

Controllers are used to achieve the stable condition of a process. the PID can be arrived in the equivalent form of a process with some time delay, we should initiate the dead time by using pade approximation method. These IMC controllers designing process are mainly depends upon two factors such as the complexity of the model and the performance requirement specified by the designer. These IMC controllers is most suitable for the single input single output discrete time systems. These IMC structure are used to eliminate the errors and used to increase the efficiency of the performance in the design of PI and PID tuning methods. The change in the PID values produces a change in the designing values and increases the efficiency of the system.

7. Genetic Algorithm (GA) Method:

Genetic algorithm (GA) is the simplest method and modern technique of tuning the controllers. It is based on optimisation technique. It is more efficient and suitable for tuning process. These genetic algorithm technique has no such formulas to calculate and determine the value of the system. Genetic algorithm is fully based on following the specific codes to obtain the specific values of the system. It also produces the effective balance by avoiding the dilemma of global optimum Vs many local optima. These genetic algorithm does not require any specific structure. The values can be obtained by choosing the random values. These genetic algorithm can be classified as selection, mutation and cross over.

The below flowchart is explained in steps:-

- Initially determine the number of chromosomes, values of generation rate, mutation rate and crossover rate
- chromosome-chromosome number of the population is determined and the initialize it with the random value
- Process the further steps specified below until the required number of generations is gathered
- Evaluation of fitness value of chromosomes by calculating objective function

- Chromosomes selection
- Crossover
- Mutation
- New Chromosomes (Offspring)
- Solution (Best Chromosomes)

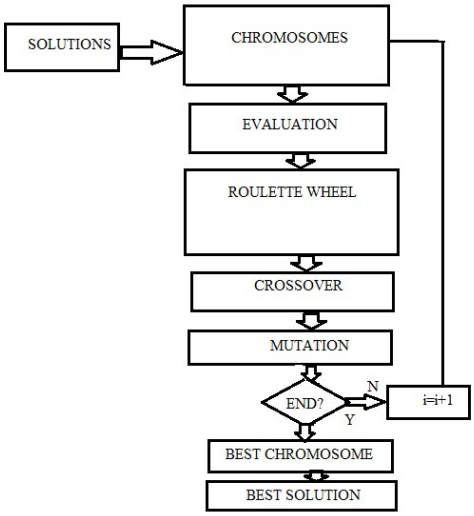

Figure 2. GA Flow Chart

Genetic algorithm plays a vital role in the real time applications. Some of the real time applications of genetic algorithms are antenna design, electronic circuits, network design etc.., it can be used for any kind of optimisation technique methods.

Table 1. Pid Values for the above Specified Significant Tuning Methods

Controller	**IMC Controller**	**GA Controller**
Proportional Term	0.848	1.5244
Integral Term	0.005062	0.0077
Derivative Term	66.992	37.96

8. Performance Error Criteria

Error criteria are considered to be the decisional parameter while concluding the best suitable controller for the relevant process which is a flow in this paper.

The performance index for the flow process is calculated using the m-file coding in MATLAB. It consists of variety of criteria which is enforced. They are

- ITAE(Integral Time Absolute Error)

  It considers the time value absolute with respect to time

$$\text{ITAE} = \int_0^T t|e(t)|dt$$

- IAE(Integral Absolute Error)

It does not consider time for the respective error values.

$$\text{IAE} = \int_0^T |e(t)|dt$$

- ISE(Integral Square Error)

  By squaring the small error value makes it smaller. Therefore to reduce the error given to the system it is implemented.

$$\text{ISE} = \int_0^T |e^2(t)|dt$$

- MSE(Mean Square Error)

  By taking the mean of all the errors, system output error due to disturbance is reduce considerably.

$$\text{MSE} = \int_0^T t|e^2(t)|dt$$

By considering all possibility of error criterion, analysis procedure is made easy.

Table 2: Comparison Of Performance Error Criterion

Controller	**IMC controller**	**GA controller**
ITAE	1.1942e+005	1.1942e+005
IAE	1.8440e+003	1.0097e+003

ISE	1.0834e+003	838.3751
MSE	0.01151	0.0579

9. Result and Comparision

The tuned values of IMC controller based PID values and GA controllers can be compared for their responses value. in real time application process, the PID based controller are the one that are suitable for the industrial applications. comparing the two controllers based on their time domain specifications, GA controllers are most suitable for the tuning value of the parameters and it can be simulated by using the MATLAB. from the response, GA controller yields a better output than the IMC based PID controller. the typical criterion based control is achieved by implementing the GA technique. the result of the GA technique is analysed by their time domain specifications and it is represented below.

Table 3: Comparison of Time Domain Specifications

Controller	**IMC controller**	**GA controller**
Rise time (seconds)	342.5	144
Peak time (seconds)	0	0
Overshoot (%)	0	0
Settling time (seconds)	1240	923

9.1. Servo Response

The below plotted graph is displayed for the determination of best controller that are used on the basis of servo characteristic of the flow process. The servo response is achieved by introducing the disturbance in terms of set point change at the input side. The figure shows how faster the setup reacts for the change in set point.

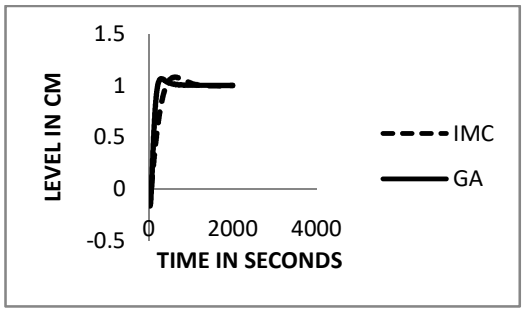

Figure 3. Servo Response

9.2 Regulatory Response

Regulatory is achieved by bringing the disturbance at the output side of the system, ie the introduction of disturbance after the controlling process, which results in the below figure. The below graph is the comparison chart of the tuning method of Internal Model Control and Genetic Algorithm. The above tabulated analysis for the controller is exhibited in the graph

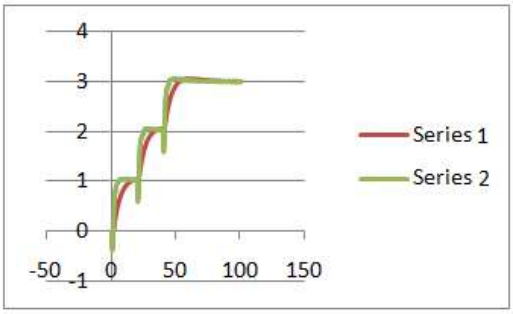

Figure 4. Regulatory Response

10. Conclusion

The level of the tank should be maintained is the most predominant working in the industries. the controller design should be effective and more important to control of process. the obtained results shows that the GA technique is better when compared to the IMC based PID

controller. The performance index under the various error criterions for the proposed controller is always less than the IMC tuned controller. the effectiveness of the GA technique in terms of time domain specifications by achieving minimum rise time, minimum peak time, minimum settling time and overshoot. hence from the above statement, we can conclude that GA technique are considered to be a better choice for liquid level control of a process tank based on PID controllers.

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