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Fuzzy PID Controller Design for a Pressure Process Station

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Abstract: This proposed work is to improve the performance of a pressure process station. By the combination of traditional PID controller and Fuzzy Logic controller, steady state in the short time is achieved. In this methodology a hybrid system in the Fuzzy PID controller is used to improve the performance of pressure process station. Comparative analysis for the performance measures for Fuzzy PID controllers are computed. From simulation result it can be found that both the overshoot and settling time are decreased to meet the required. In the conclusion Fuzzy PID control method can improve dynamic response of pressure process station effectively. Performance of PID controller is better than Fuzzy PID controller.

Keywords: Pressure Process Station, PID Controller, Fuzzy PID Controller.

I. INTRODUCTION

Control of industrial parameters is a challenging task for several reasons due to their nonlinear dynamic behaviour, uncertain and time varying parameters, constraints on manipulated variable, interaction between manipulated and controlled variables, unmeasured and frequent disturbances, dead time on input and measurements. Pressure control is mode of mechanical ventilation alone and a variable within others modes of mechanical ventilation. Pressure control is used to regulate pressures applied during mechanical ventilation. Pressure vessels are used in a variety of application in both industry and the private sector. They appear in these sectors as industrial compressed air receivers and domestic hot water storage tanks. Examples of pressure vessels are driving cylinders, recompression chambers, distillation towers, pressure reactors, autoclaves and many other vessels in mining operations, oil refineries and petrochemical plants, nuclear pressure reactor vessels, submarine and space habitats, pneumatic reservoirs, and storage vessels for liquefied gases such as ammonia, chlorine and LPG (propane, butane) which is discussed in detailed by xingjun.

The PI and PID controllers are widely used in many industrial control systems because of its simple structure. When it comes to the control of nonlinear and multivariable processes, the controller parameters have to be continuously adjusted. The classical controllers like PI or PID controllers are widely used in process industries because of their simple structure assure acceptable performance for industrial processes and their tuning is well known among all industrial operators. However, these controllers provide better performance only at particular operating range and they need to be retuned if the operating range is changed. Further, the conventional controller performance is not up to the expected level for nonlinear and dead time processes. In the present industrial scenario, all the processes require automatic control with good performance over a wide operating range with simple design and implementation.

In this project the system model is found by using the open loop data the model transfer function is obtained using system identification tool. The Ziegler-Nichols of PID is designed and Tyreus Iyuben, IMC are designed. Model Reference Adaptive Control is implemented using the platform of MATLAB/SIMULINK environment and the results are compared.

II. HARDWARE AND DESCRIPTION

The block diagram which explains that the system with three parts with Computer, Data acquisition card and Pressure process that is given below in figure 1.

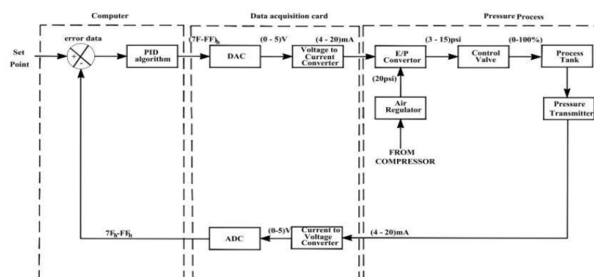


Fig.1 Block diagram of pressure process

Pressure process controller is used to perform the control action on pressure process. In this unit pressure is the process variable and is sensed and given to controller. A Piezo-electric pressure transmitter is used to measure and transmit the pressure developed in the process tank, in this unit, pressure is developed from a compressor and is given to the unit. Every internal transaction is in voltage. Here, PC acts as error detector and controller. According to the error signal, computer develops a control signal. This control signal is given to I/P Converter which operates the control valve, these are take place in the pressure station which is given in Fig. 2



Fig. 2. Pressure process station

Control valve acts here as final control element which controls the pressure inside the process tank by varying its plug opening according to the controller output. Data Acquisition card has ADC and DAC, so that it acts an effective link between the process and the controller. Relief valve is being used for safety purpose by which excess pressure developed in the process tank can be removed.

III. SYTEM MODELING

Run open loop program in MATLAB Simulink which is connected to the pressure process system and save the data to the MATLAB workspace. Open the system identification toolbox in MATLAB by typing indent in the command window. Import the input and output which is taken from the open loop implementation. Then choose the process model for the imported data and give estimate to view the process transfer function. By using this method the transfer function is obtained for the pressure process analyzers is given in Equation (3.1)

$$G(s) = \frac{0.05574}{S + 1.163e - 10}$$

A. The Characteristics of P, I, D Controllers

A proportional controller K_p will have the effect of reducing the rise time and will reduce, but never eliminate, the steady-state error. An integral control K_i will have the effect of eliminating the steady-state error, but it may make the transient response worse. A derivative control K_d will have the effect of increasing the stability.

Table 1 Conventional PID controller tuning parameters

Close Loop Response	Rise Time	Overshoot	Settling time	Error Steady state
K_p	Decrease	Increase	Small change	Decrease
K_i	Decrease	Increase	Increase	Eliminate
K_d	Small change	Decrease	Decrease	Small change

IV. FUZZY PID CONTROL

The term fuzzy refers to the fact that the logic involved can deal with concepts that cannot be expressed as the true or false but rather as partially true. Although alternative approaches such as genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases, fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller.

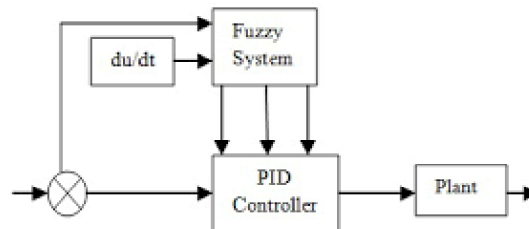


Fig. 3 Block Diagram of Fuzzy PID Controller

This experiment we use FLC to improve the stability of the pressure process station. We used 9 fuzzy rule base and the fuzzy PID controller has the following parameter.

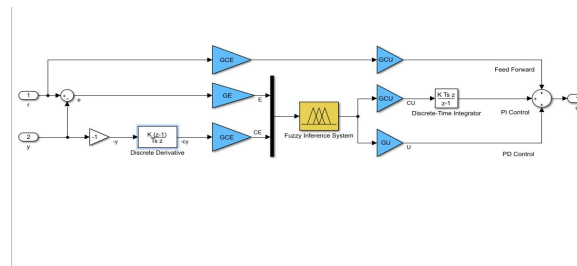


Fig.4 Fuzzy PID controller block diagram on Simulink

V. RESULTS AND DISCUSSION

In this chapter different controller tunings and their simulation results are discussed. Simulation is used to analyse an optimal process operation, safety, environmental constraints. When the process is in operation, it is used to analyses, test and optimize operating conditions. It ensures the safety of the operator as well as the hardware system. So before implementing the controller design in real time, it is necessary to

A. Open Loop Response

The open loop response is taken in real time with no feedback loop and Process model is found by this method and the response is given in Fig. 5.

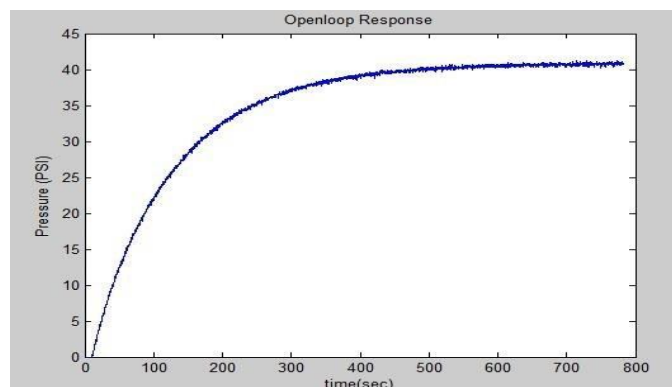


Fig. 5 Open loop response

B. Ziegler Nichols PID Response

The PID Controller is tuned using ZN tuning, the tuning parameters obtained are $k_P = 1.08372$ sec $\tau = 0.0649$ sec Response of PID Controller

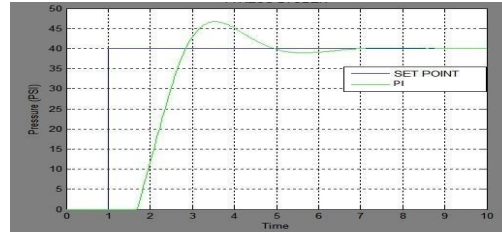


Fig. 6 Simulated response of PID Controller

The PID controller attempts to minimize the error by adjusting the controller output. The PID gain values are calculated by using the Ziegler Nichols open loop tuning algorithm. This method is one of the classical method in PID controller.

C. Step Response of PID Control

Nonlinear model with SISO configuration is shown in the below Fig. 7.

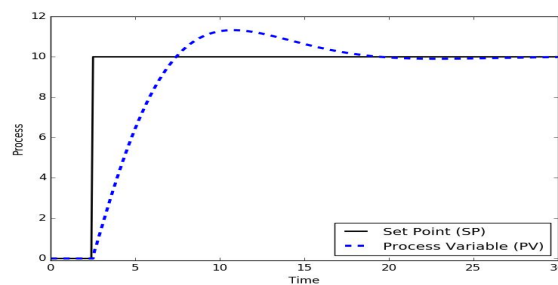


Fig 7 Model output of PID control

According to Fig 7, the settling time is 52.89s and %of the overshoot. So the response result is not satisfactory. For this reason, this experiment add the Fuzzy controller to reduce the settling time and overshoot.

D. Step Response of Fuzzy PID Control

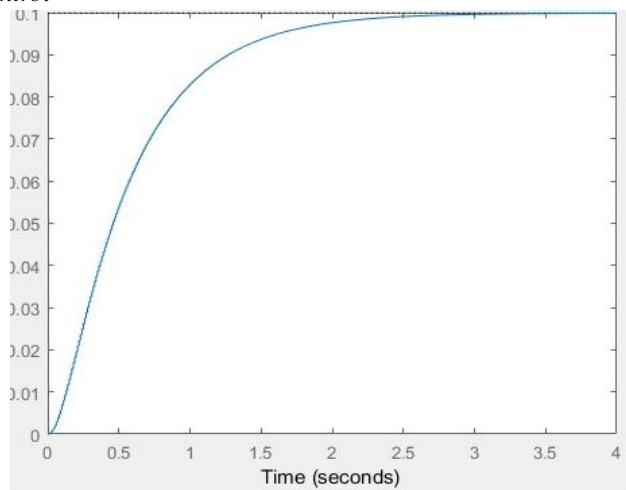


Fig 8 Model output of Fuzzy PID control

According to fig 8, We can know the fuzzy controller demonstrate good effect. The settling time is 1.03s and the dynamics response of system reaches to the steady state quickly.

VI. CONCLUSION AND FUTURESCOPE

The controlling of nonlinear system is a very challenging task to perform. In this work, model is obtained for a hybrid of intelligent controller for improving the stability of pressure process station. In Fuzzy PID controller, the PID controller is the main controller and the Fuzzy controller is the auxiliary controller. It is observed that the rising time is almost the same, but the overshoot reduced and the settling time is shorter than PID controller. It is to represent that the stability of the system is better. Performance of Fuzzy PID controller is better than Fuzzy PID controller. The different controllers are verified using simulation only. These controllers can be implemented in real time and the response can be analyzed. We will utilize Genetic Algorithms to find the optimal parameter. The system of dynamic response made more quickly and stable to further improve the performance of Fuzzy PID controller in near future.

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