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PID Based Temperature Control of a Plant Heat Exchanger System

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Abstract: **This paper aim is to design a controller for controlling the Temperature Heat Exchanger process of a plant .The effects of the controller on heat exchanger is analyzed .Automatic tuning of the controller is also introduce for efficient control of the process .The tuning is implemented using Ziegler Nichols method and results are compared with Variation in temperature without controller.**

Keywords: **PID, Tuning, Ziegler Nichols, Heat Exchanger system.**

1. INTRODUCTION

In practice, all chemical process involves production or absorption of energy in the form of heat. Heat exchanger is commonly used in a chemical process to transfer heat from the hot fluid through a solid wall to a cooler fluid. . They have larger ration of heat transfer surface to volume than double pipe heat exchangers, and they are easy to manufacture in large variety of sizes and configuration. They can operate at high pressure, and their construction facilitates disassembly for periodic maintenance and cleaning. Heat exchanger find widespread used in refrigeration, power generation, heating and air-conditioning, chemical process, manufacturing, and medical application. A heat exchanger in an extension of the double pipe configuration. A classical PID controller is implemented in a feedback control loop so as to achieve the control objectives. Different assumptions have been considered to develop the control architecture of the shell and tube heat exchanger system. The first assumption is that the inflow and the outflow rate of fluid are same, so that the fluid level is maintained constant in the heat exchanger. The second assumption is the heat storage capacity of the insulating wall is negligible. In this feedback process control loop, the controller is reverse acting; the valve used is of air to open (fail-close) type. A thermocouple is used as the sensing element, which is implemented in the feedback path of the control architecture. The temperature of the outgoing fluid is measured by the thermocouple and the output of the thermocouple (voltage) is sent to the transmitter unit, which eventually converts the temperature output to a standardized signal in the range of 4-20 mA. This output of the transmitter unit is given to the controller unit. In this heat exchanger system a PID controller has been taken as the controlling unit. The PID controller implements the control algorithm, compares the output with the set point and then gives necessary command to the final control element via the actuator unit. The actuator unit is a current to pressure converter and the final control unit is an air Conventional Controllers to open (fail-close) valve. The actuator unit takes the controller output in the range of 4-20 mA and converts it into a standardized pressure unit, i.e in the range of 3-15 psig. The valve actuates according to the controller decisions.

2. PID CONTROLLER

The mnemonic PID refers to the first letters of the names of the individual terms that makeup the standard three-term controller. These are P for the proportional term, I for the integral term and D for the derivative term in the controller. Three-term or PID controllers are probably the most widely used industrial controller. Even complex industrial control systems may comprise a control network whose main control building block is a PID control module.

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PID controllers are widely used in process control industry due to relatively simple structure and easiness in implementation. Since last few decades different methods are proposed to tune PID controller, however, every method have some limitations. Existing control loop uses PID controller more than 90%. As a result, the design of PID controller still remains a challenge before researchers and engineers.

To design and tune the controller to achieve the better performance it is essential to,

1. Obtain the dynamic model of a system to control.

2. Specify the desired closed loop performance on the basis of known physical constraints.

3. Adopt controller strategies that would achieve the desired performance.

4. Implement the resulting controller using suitable platform.

5. Validate the controller performance and modify accordingly if required.

3. HEAT EXCHANGER SYSTEM

A typical interacting chemical process for heating consists of a chemical reactor and a shell and tube heat exchanger system. The super-heated steam comes from the boiler and flows through the tubes. The process fluid which is the output of the chemical reactor is stored in the storage tank. The storage tank supplies the fluid to the heat exchanger system .The heat exchanger heats up the fluid to a desired set point using super-heated steam supplied from the boiler. The storage tank supplies the process fluid to a heat exchanger system using a pump and a non returning valve. There is also a path of non-condensed steam to go out of the shell and tube heat exchanger system in order to avoid the blocking of the heat exchanger. In several systems the disturbance can be predicted and its effect can be eliminated with the help of feed forward controller before it can change the output of the System. In feedback control scheme the sensor detects the process output and gives the error to the controller, which in turn takes appropriate controlling action. But till the controlling action reaches the process, the output has been changed. So a feed forward controller along with the feedback controller has been implemented. A feed forward control estimates the error and changes the manipulating variable before the disturbance can affect the output. To further minimize the overshoot a feed-forward controller is introduced in the forward path of the process along with the feedback controller. The combined effect of feedback and feed forward controller reduces the overshoot value.

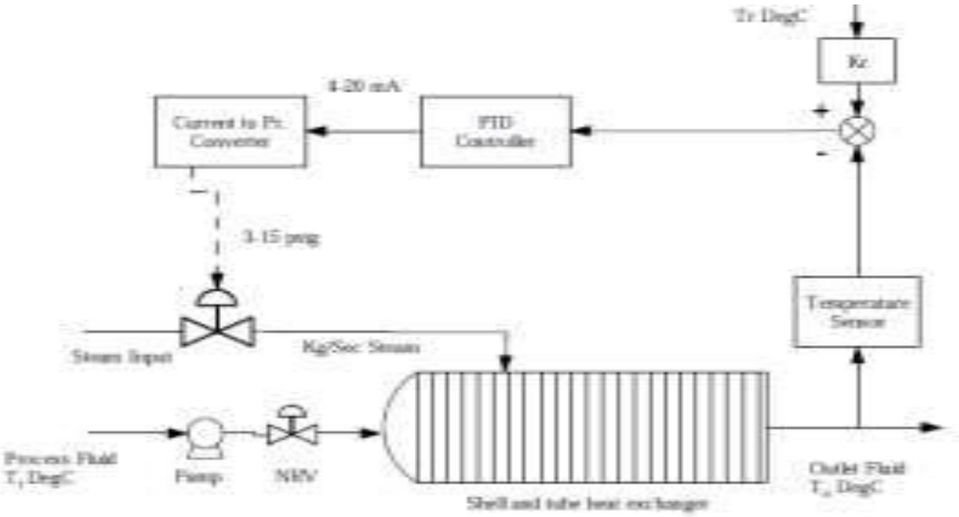

Fig.1 Heat Exchanger System

In this section the heat exchanger system, actuator, valve, sensor are mathematically modeled using the available experimental data. The experimental process data’s are summarized below:

Exchanger response to the steam flow gain -50^{0}C/Kg/Sec

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Time constants -30 sec

Exchanger response to variation of process fluid flow gain-1^{0}C/Kg/Sec

Exchanger response to variation of process temperature Control valve capacity for steam -1.6 Kg/Sec

Time constant of control valve - 3 Sec

The range of temperature sensor – 50^{0}C to 150^{0}C

Time constant of temperature sensor -10 Sec

From the experimental data, transfer functions and the gains are obtained as below.

$$G(S)=\frac{0.2304S+0.01265}{S^2+0.0689S+0.005244}$$

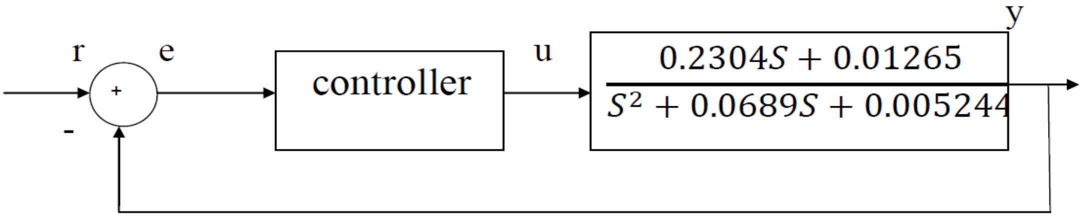

Fig.2. Mathematical model of heat exchanger with controller

The response of plant without controller is shown in figure below. The rise time so obtain is greater than 0.943sec.

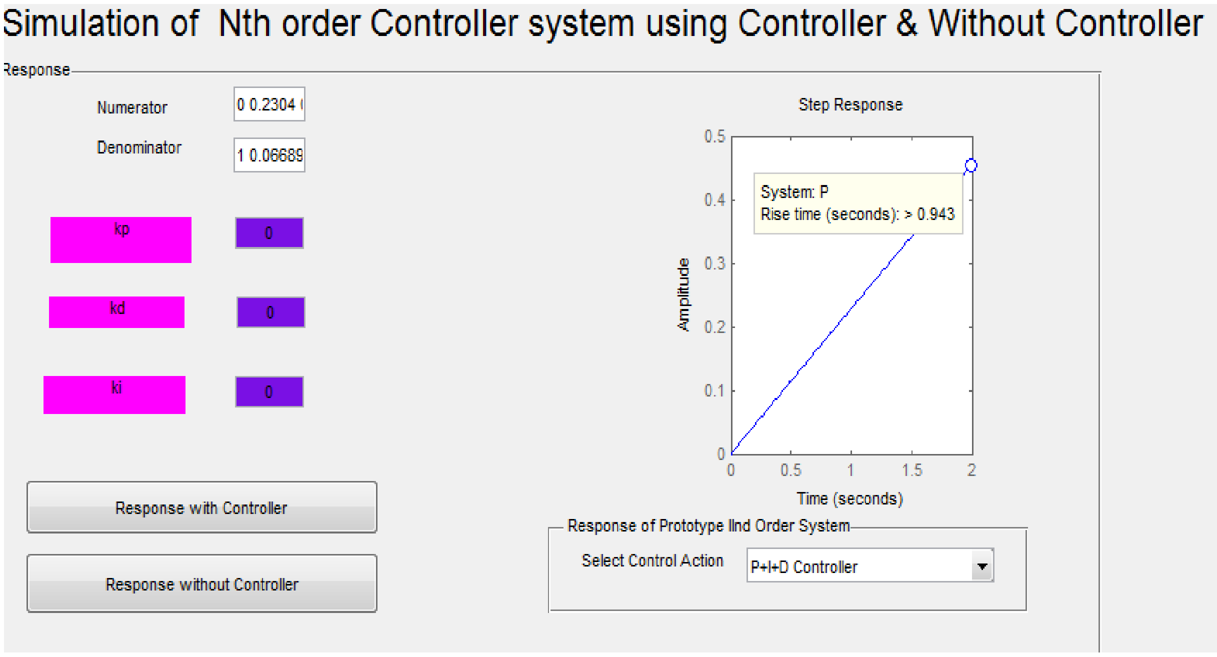

Fig 3. Response of system without controller

The values of K_P,K_d,K_I obtain from Ziegler nichols tuning is applied to the controller transfer function and results so obtain are given in graph below. Values of K_P=5.0301,K_d=0,K_I=4.0153 substitute these values for PID and analyse the result.

Table. 1. Comparison of performance parameter with different controller and without controller

	RISE TIME	SETTLING TIME	%OVERSHOOT
WITHOUT CONTROLLER	>0.943 sec	2.03sec	0%
P	1.32sec	20.3sec	4.79%
P+I+D	0.938sec	7.37 sec	23.7%

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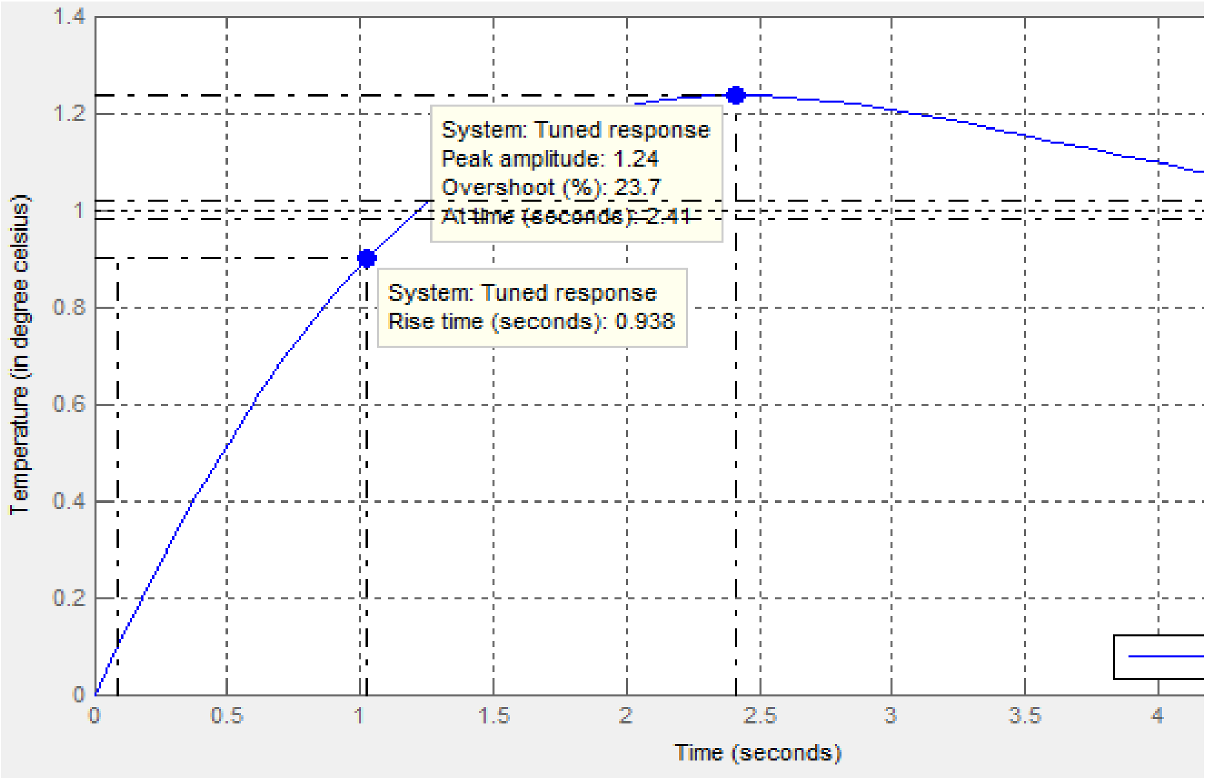

Fig.4. Response of System using PID controller

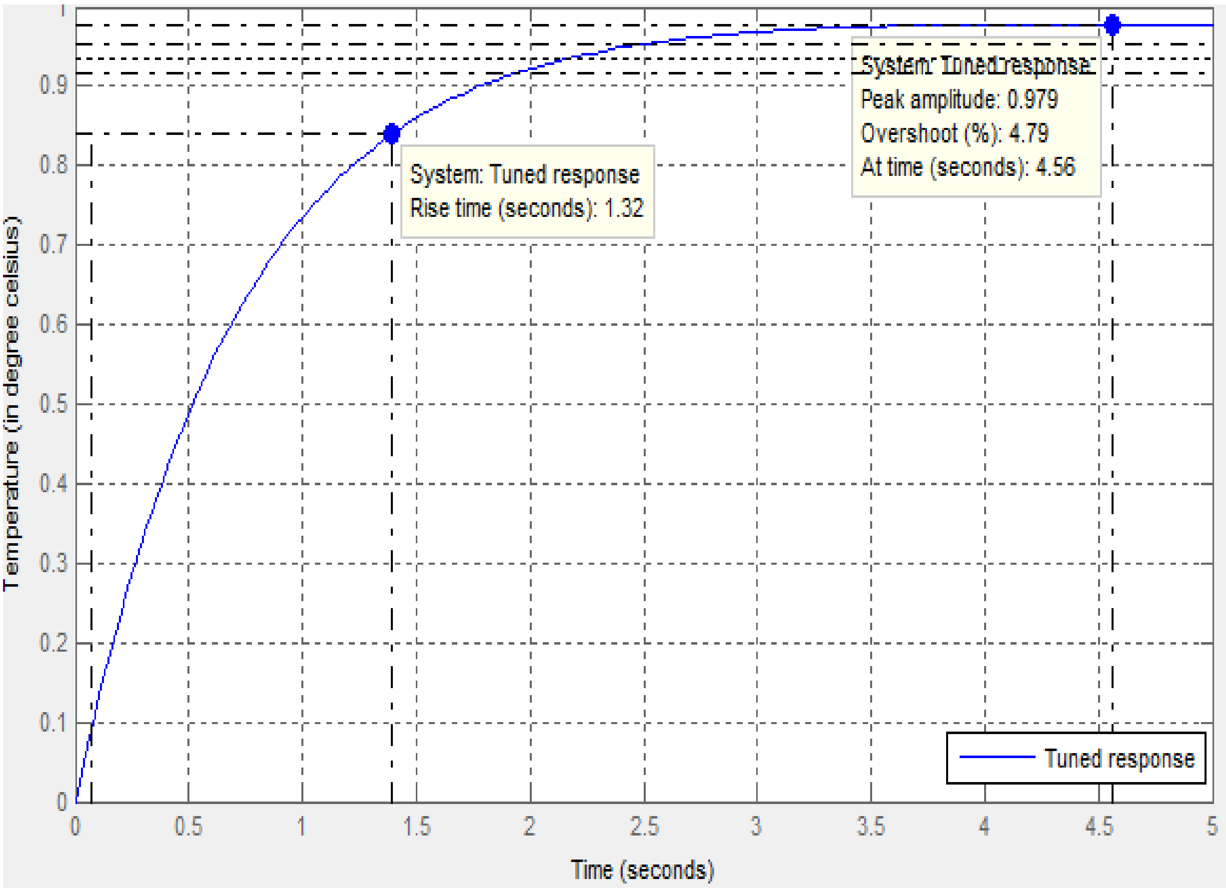

Fig.5 Response of system using PI controller

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