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Reactor Automation Temperature Control Using PID

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Abstract: This paper is based on the design of PID controller using Programmable Logic Controller (PLC) in reactor automation plant. PID controller is design by using ladder diagram in PLC micrologix 1400. A temperature control unit temperature transmitter is also used where the temperature control unit is a special I/O unit that receives inputs directly from them, to perform PID control. Desired temperature or set point (SP) is set by the user using the SCADA (Supervisory Control and Data Accusation) and programmable logic controller will try to maintain the current temperature base on the set point temperature set by the user from SCADA. Temperature control is very difficult to be by using ordinary control techniques; hence the purpose perform PID controller implemented using programmable logic controller (PLC) in order to control the time to heating, cooling & chilling up to a particular a desired temperature set point. A complete analysis using different type of PID parameters is presented in terms of system response. Performance of the controller is examined in terms of temperature settling time, temperature rise time and temperature of percent overshoot.

Keywords: Programmable Logic Controller (PLC), Proportional-integral-derivatives (PID) Controller, Human Machine Interface (HMI).

I. INTRODUCTION

In chemical industries, pharma industries, food industries most important to improve product quality for that purpose it is most important to control temperature of the reactor or vessel. In previous days they use temperature control unit or manually they control but sometimes because of temperature overshoot product are damaged, hence the main purpose of reactor automation is control reactor temperature. Using different types of utilities like steam, hot water, cold water, chilled brine, Hence system is heating and cooling up to particular solution and desire temperature with the quickest time constant and minimum overshoot, in other word Most conducive to a favorable outcome. The system operates in a closed loop system to ensure the desired temperature will be obtained in fastest time and accurately. PID Controller requires the best knowledge of tuning the to find the best value of PID.

Proportional-integral-derivative controller is widely used in process control industry due to its Simplicity in structure and ease of implementation, Although the control theory and method has got great progress, PID controllers are still common and well known method. Mostly chemical industry, metallurgical industry and food industry show that 97% of the controllers select PID structure. An important objective of control system design is to minimize the effects of external disturbances. The problem is if disturbance arises in many industrial fields, such as motion control, active noise control and vibration control.PID calculates the differences between the desire value and the actual value, by using the error calculated, it attempts to minimize it by adjusting the control input to obtain the desire output value. By tuning the 3 parameters in PID, the controller can provide specific control action designed for different requirements. In the field of metallurgy, chemistry, food industries and oil refining due to the time delay and process parameter uncertainty, the parameter of PID controller need automatic adjustment.

The proportional i.e. output value is proportional to the error value. Error value means difference between set point and process variable. The proportional response can be adjusted by multiplying the error by a constant Kp, called the proportional gain constant. High proportional gain results are a large change in the output for a given change in the error. Proportional gain is too high, the system can become unstable. Proportional gain is too low the control action may be too small.

The integral term is proportional to both the duration of the error and magnitude of the error. Integral term accelerates of the process towards set point and eliminates the residual steady-state error that occurs in proportional controller; hence integral term responds to accumulated errors from the past it can cause the present value. In a PID controller is the sum of the quick error over time and gives the accumulated offset that should be corrected previously. The accumulated error is then multiplied by the integral gain and added to the controller output.
The derivative of the error is calculated by the slope of the error over time and multiplying this rate of change by the derivative gain Kd. The magnitude of the contribution of the derivative term to the overall control action is

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termed the derivative gain Kd. Derivative action predicts system behavior and thus improves settling time and stability of the system. Derivative value determines the reaction based on the Rate at which the error has been changing. Adding a derivative term can improve the stability, reduce the overshoot that rises when proportional or high gain integral terms are used, and improve response speed by predicting changes in the error However, difference between signal amplifies noise and thus this term in the controller is highly sensitive to noise in the error term. The most common used controllers are the P controller, PI controller and PID controller. Proportional controller proportional term should produces bulk of the output change. And capable of minimizing the rise time. However it never eliminates the steady state error. Proportional-integral Controller on the other hand will eliminate the steady state error. A Proportional-integral-derivatives controller will improve the system reduce the overshoot, stability, and improve the transient response.

II. METHODOLOGY

The project overview is shown in Fig. 1. Where the block Diagram of this project, showing how temperature transmitter, SCADA, PLC, control valve, on-off valve. These all instruments are in system communicate with each other in closed loop system for temperature control of reactor. The input or set point.(SP) of the system is the desired temperature and analyses for different kind of PID gain are done in order to get the best PID gain parameters. And Fig. 2 shows the project flow chart of the system.

Where the block diagram of this project, showing how SCADA,PLC, PID, control valve, utility and temperature transmitter are related to each other to form a closed loop system.

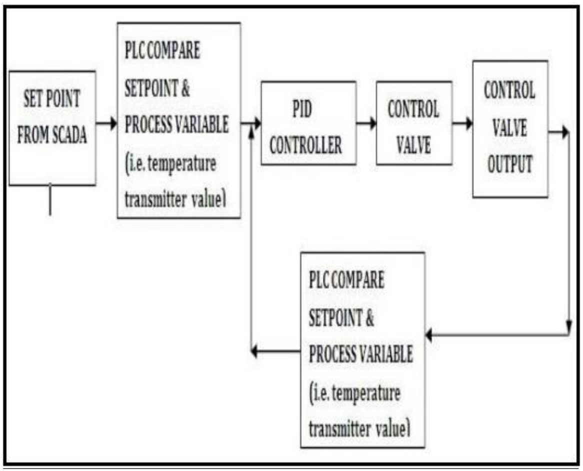

Figure 1 Project overview

Methodologies of this project is temperature control of reactor using PID controller.PID controller is developed by PLC ladder logic diagram below shows the first you decided the which cycle we wants i.e. Heating cycle ,cooling cycle, chilling cycle. In these cycle first set the temperature set point of reactor then set time for cycle on particular column and then press start after cycle start first start the on-off valve. Then PLC calculate the error value between temperature set point and temperature current value after calculating these as per error value control Valve will open and after achieving temperature value control valve will be close. After achieving temperature set point timer will start and after completion of timer cycle will over and cycle automatic stop.

As discuss above there are three cycle heating cycle, cooling cycle, and chilling cycle. In heating cycle there are two cycle steam cycle and hot water cycle, In cooling cycle there are also two cycle cold water cycle and chilled brine cycle. And one more cycle is there it's not temperature control cycle its flushing cycle which is main use is flush out the jacket utility from reactor jacket.

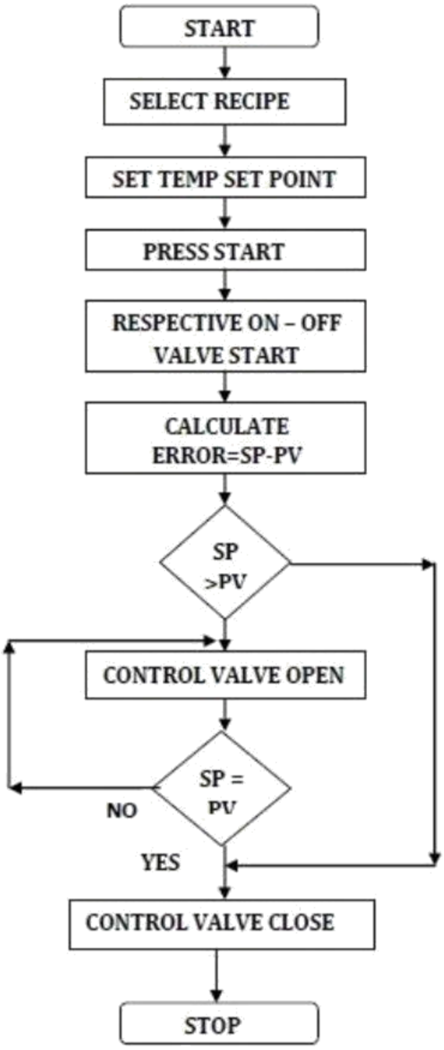

Figure 2 Project flow chart

In terms of the hardware programming, this project Involved two part of hardware programming which are PLC Ladder diagram programming and Human Machine

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Interface (HMI) programming. The details explanations of each part are

PLC Ladder Diagram Programming
Rs logix500-Programmer is one of the software used for this Project. This software will enable the communication between the hardware which are the temperature transmitter, control valve SCADA and on-off valve and the PLC in order to control the temperature to the desired value by using ladder diagram programming. Below fig shows rs logix programming software.

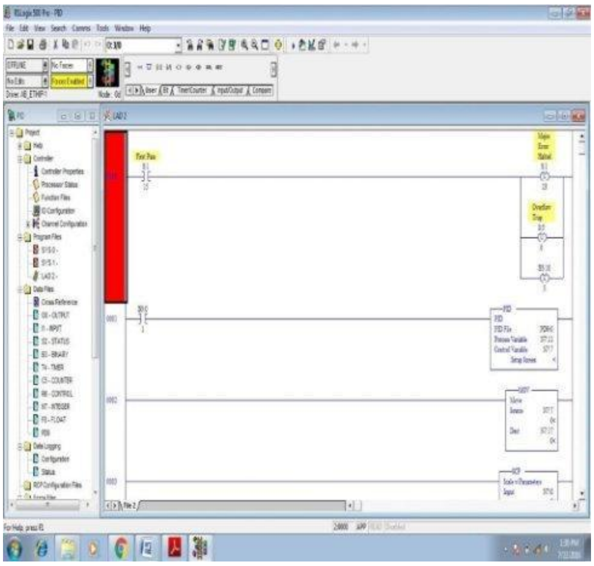

Figure 3 PLC programming

In order to communicate between the PLC and the Heating tank, ft view SCADA supervisory control and data acquisition is used. SCADA system design is shown below.

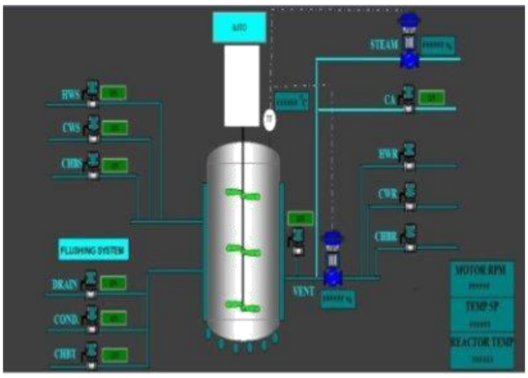

Figure 4 P&I DIAGRAM

In this system above fig shows the reactor automation it shows the reactor image in that reactor has jacket for utility supply and utility like heating, cooling and chilling is used for the powder making under reactor. We see the agitator under reactor agitator is used for the mixing powder of reactor and Agitator is operating with help of motor. Motor operation is manually from SCADA in auto mode or manual mode any mode. We can operate motor any time in process.

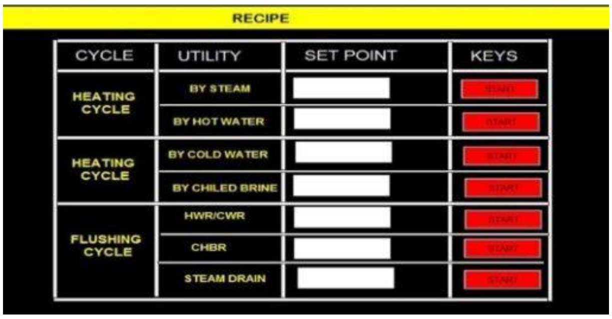

Figure 6 recipe screen

From these screen we can set the recipe as per our requirement .from these screen we can select and start recipe like heating cycle, cooling cycle and flushing start .In heating cycle we heat by steam and by hot water. In cooling cycle we cool by cold water and chilled by chilled brine. In flushing cycle include HWR/CWR flushing, CHBR flushing, steam drain.

III. RESULTS

In this section we describe the result foe every cycle

Steam cycle
In steam cycle operate steam control valve and condensate valve and PID controller operate in forward bias, hence they calculate error between set point and process variable.

SETPOINT (^{0}C)	PV (^{0}C)	ERROR (SP-PV) (^{0}C)	CV OPEN %
100	20	80	100
100	30	70	100
100	40	60	100
100	60	40	90
100	80	50	30
100	95	5	10
100	100	0	0

Hot water cycle
In hot water cycle operate hot water supply and hot water return valve and utility control valve and PID controller operate in forward bias, hence they calculate error between set point and process variable

SETPOINT (0C)	PV (0C)	ERROR(SP-PV) (0C)	CV OPEN %
50	10	40	100
50	15	35	90
50	20	30	80
50	25	25	65
50	30	20	25
50	40	10	10
50	50	0	0

Cold water cycle

In hot water cycle operate hot water supply and hot water return valve and utility control valve and PID controller operate in reverse bias, hence they calculate error between process variable and set point

SETPOINT (0C)	PV (0C)	ERROR(PV-SP) (0C)	CV OPEN %
25	60	35	100
25	55	30	90
25	50	25	70
25	40	15	40
25	35	10	· 20
25	30	5	· 10
25	25	0	. 0

IV CONCLUSION

Investigations into implementation of PID controller using Programmable Logic Controller (PLC) in heating tank of mini automation plant have been presented. Performance of the controller is examined in terms of settling time, rise time and percent overshoot. The results demonstrated that the PID Controller can handle the system well. From the analyses that have been done, a significant improvement in the system Performance has been achieved with PID controller as compared to P and PI controller. It can be concluded that the best PID parameters for the system is P=53 I= 871 D=150.

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