Design And Analysis of PID Controller For CSTR Process

Nikul Maheshwari, Neha Jain, Arun Jingar, Mahendra Suthar

Abstract— **Continuous Stirred Tank Reactor (CSTR) is an important topic in process control and offering a diverse range of researches in the area of the chemical and control engineering .We will present two different control strategies based on PID control. We will use tuning method Good gain method to tune the parameter of PID. The objective is to control temperature and load disturbance rejection of CSTR. The model is going to be in MATLAB SIMULINK software. Here we also design discrete PID controller for CSTR.**

***Index Terms*— PID controller, Good Gain Method, CSTR.**

I. INTRODUCTION

Continuously stirred Tank Reactor (CSTR) with a recirculating jacket heat transfer system may have more interesting dynamic behavior than a classical representation of a "jacket. A particular CSTR with a single steady – state as a function of jacket temperature may have multiple steady state behavior if the jacket inlet temperature is considered the manipulated.[1] The PID controller is the most common form of feedback. It was an essential element of early governor and it became standard tool when process control emerged in 1940s.The controller come in many different forms. The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). The Proportional, Integrating, and Derivative terms to sum-med to be calculate the output of the PID controller.[2] We can achieve good performance for both Load disturbance rejection & temperature of CSTR it contain standard PID controller in the feedback loop and adds a pre-filter to its reference signal. The pre-filter helps to produce a smoother transient response to set point change. in this we will used PID Simulink controller block to control a continuous stirred tank reactor . In this Project CSTR has used to be production of propylene glycol by hydrolysis of propylene with sulphuric acid as catalysis. Water is supplied in access, so reaction is of first order.

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II. CASE STUDY

Chemical kinetics and reactor design are at the heart of producing almost all industrial chemicals. The selection of a reaction system that operates in the safest and most efficient manner can be the key to the success or failure of a chemical plant. The reaction occurred in a reactor is exothermic or endothermic. The reactor is generally assembled with a jacket or coil in order to maintain the reaction temperature in the reactor. If heat is evolved due to exothermic reaction, a coolant stream is required to pass through the jacket or coil to remove the extra heat. On the other hand, if endothermic reaction occurs in the system, the flow of heating medium is passing through jacket or coil for maintain the reaction temperature.[3] A reactor operates at a constants temperature, then that is called as the isothermal reactor. If any exothermic or endothermic reactions are involved in the reactor, the temperature of the reactions mixture varies with time and we need to develop the energy balance equation for this non-isothermal reactor.

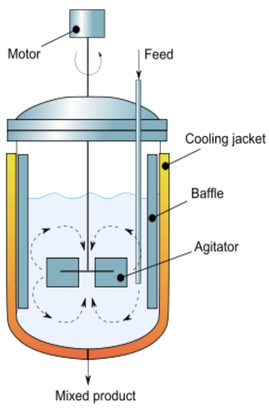

Figure 1. Continuous stirred Tank Reactor with Cooling Jacket.

III. STEADY STATE SOLUTION

The steady state solution is obtain when dCA/dt=0, dT/dt=0, dTj/dt=0 that is

fI(CA,T,Tj)=dCA/dt=0=F/V(CAf –CA)-Koexp(-E/RT)CA..(1.1)

f2 (CA, T, Tj) =dT/dt=0=F/V (Tf-T) + (-ΔH/ ρ CP) Koexp (-Ea/RT)C_A -UA (T-Tj)/V ρ C_p …………………..(1.2)

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Parameter	Value	Unit
Ea	32.400	Btu/Ibmol
K_o	$16.96*10^{12}$	Hr^{-1}
U	75	Btu/hrft ^{2} F
Pc_p	53.25	Btu/ft ^{3o} F
R	1.987	Btu/Ibmol ^{o} F
F	340	Ft^3/hr
V	85	Ft^3
Ca_f	0.132	Lbmol/ Ft^3
T_f	60	^{o} F

Table 1, Table for reactor Parameter Value

IV. PROBLEM FORMULATION

The modal of linearization procedure is to find a model with the form[1]

$$\dot{X} = Ax + Bu \quad \text{………………….……….} \ (1.3)$$

$$Y = Cx + Du \quad \text{……………..……….} \ (1.4)$$

Where, the states, input and output are in deviation variable.

$$A=\begin{bmatrix} \partial f1/\partial x1 & \partial f1/\partial x2 \\ \partial f2/\partial x1 & \partial f2/\partial x2 \end{bmatrix}$$

$$B=\begin{bmatrix} \partial f1/\partial u1 \\ \partial f2/\partial u1 \end{bmatrix}$$

$$C=\begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$D=\begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Using all reactor parameter's value we can find the following

State space model system-

$$A=\begin{bmatrix} -7.9909 & -0.013674 \\ 2922.9 & 4.5564 \end{bmatrix}$$

$$B=\begin{bmatrix} 0 \\ 1.4582 \end{bmatrix}$$

$$C=\begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$D=\begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

By MATLAB command we can find out reactor process transfer function (Gp).

$$G_p = \frac{1.4582s + 11.65}{s^2 + 3.434s + 3.557} \quad \text{…………}(1.5)$$

V. STABILITY ANALYSIS

The stability of particular operation point is determine by finding the A-matrix for that particular operation point and finding the Eigen value of A-matrix.[1]

$$A=\begin{bmatrix} -7.9909 & -0.013674 \\ 2922.9 & 4.5564 \end{bmatrix}$$

$$A=\begin{bmatrix} -7.9909, & -0.013674, & 2922.9, & -4.5564 \end{bmatrix};$$

Y=eig(A);

Y=-6.2737
-602737

Both the Eigen values are negative, indicating that the point is stable.

VI. SIMULATION TESTING AND RESULT

The MATLAB simulation results for controller algorithm. Here a practical result of CSTR speed control is projected. Here responses of CSTR in open loop and in closed loop, set-point tracking has been shown by figure. And also response of CSTR under Load Rejection Technique and Temperature controller output are shown.

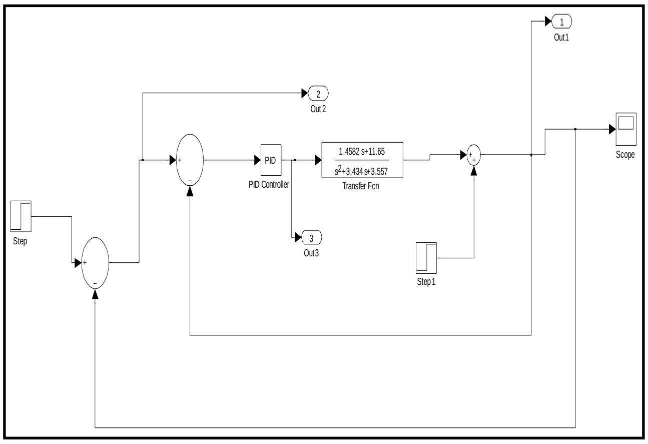

Figure2.Disturbance Rejection of CSTR Using Discrete PID controller

In this Model Of continuous PID controller The Transfer Function Is $\frac{1.4582s + 11.65}{s^2 + 3.434s + 3.557}$ So Using Good Gain Method for PID Tuning Parameter We Get the value Ki=5.4,Ti=2.4,Td=.11 [4][5]. So Through this PID parameter the Results are as Following graph (waveform), which shows for different set-point tracking as well as load disturbance rejection.

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Set point Tracking Using PID Controller

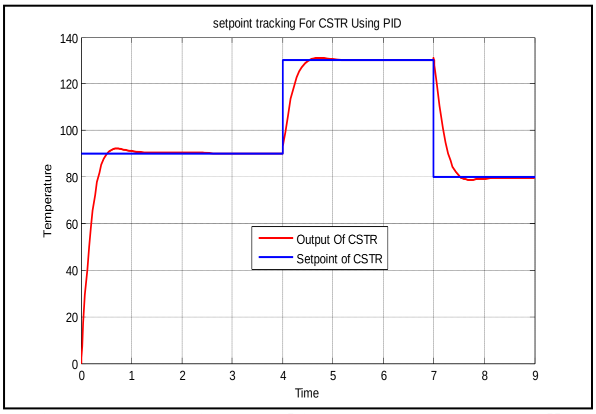

Figure 3.Set Point Tracking Using PID Controller.

In this figure set point tracking using PID controller X label indicate "time". Y label "Temperature" the red line show a output of CSTR And blue Line show a set point Of CSTR. The Output is tracking at 3-different set point. Here we given set point is at 90, 130& 80 temperature.

Model For Discrete PID Controller

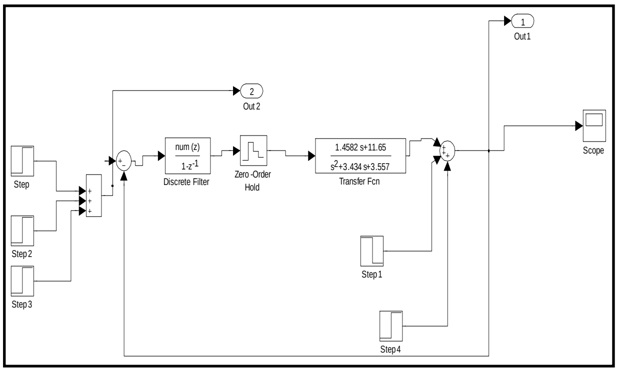

Figure 4. Model for Discrete PID Controller

In this model for a discrete PID we have taken a transfer function $\frac{1.4582s+11.65}{s^2+3.434s+3.557}$ using Good gain method. In this model we took three different set point. For input PID Tuning Parameter We Get the value Ki=5.4,Ti=2.4 sec, Td=.11 sec.

Set Point tracking using Discrete PID controller:

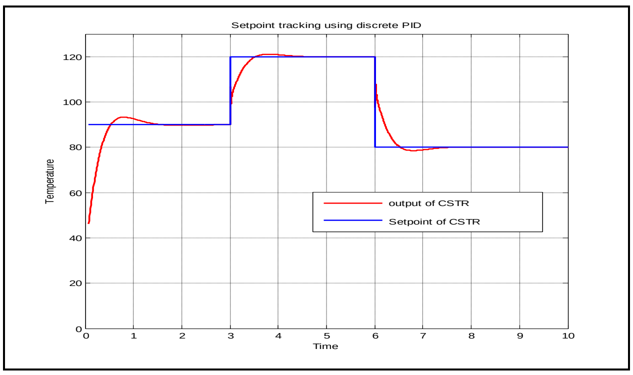

Figure 5. Set Point Tracking using discrete PID controller

In this diagram the set point tracking using Discrete PID controller at the x label indicate the time & the y Label Indicate the Temperature.

As Like as RED Line shows the output of CSTR and the Blue line shows the Set point of CSTR in this we can see that the input is given different step point at different time. The settling time in this system shown as 1.4.

Disturbance Rejection of CSTR Using Discrete PID controller:

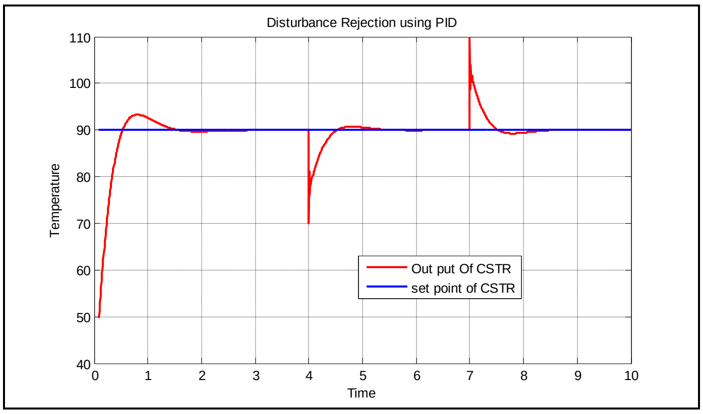

Figure.6. Disturbance Rejection of CSTR Using Discrete PID controller.

In this diagram the set point tracking using Discrete PID controller at the x label indicate the time &the y Label Indicate the Temperature.

As Like as RED Line shows the output of CSTR and the Blue line shows the Set point of CSTR in this we can see that the input is given different step point at different time. The settling time in this system 1.4sec.

VII. ANALYSIS

Parameter	**PID Controller**	**Discrete PID Controller**
Percentage Overshoot	1.11 %	3.33%
Settling Time	1.25 sec	1.4 sec
Load Disturbance Rejection	Good	Good
Quality Of Response	Less Overshoot	Less Overshoot

Table 2 Analysis of response of PID and Discrete PID controller

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VIII. CONCLUSION

An effort is made to design a control proposal satisfying the two fold purpose of control. As seen from the analysis and plots the new design having a PID control has far reaching results. Clearly the system performs better under PID control with a very less percentage overshoot and good load disturbance rejection with a minimum settling time.

REFERENCES

[1] Sandeep, g.k.p., "Temperature Control of CSTR using PID & PID controller", Trans IJARCSSE Vol.2, issue 5 May 2012

[2] Cohen, G.H., Coon, G.A. "Theoretical consideration of regard control", Trans ASME vol. 75, pp.827-834, 1953

[3] Ruiyao Gao, O'dywer A, Coyle E, "A nonlinear PID controller for CSTR using Local model networks", *intelligent control and and automation 2002.*

[4] K.H. Ang, G. Chong and Y. Li, "PID control system analysis, design and technology," *IEEE transaction on Control System Technology, Vol.13, No.4,* 2005, pp. 559-576

[5] F. Haugen, "The Good Gain method for simple experimental tuning of PI controllers", 2012 *Norwegian Society of Automatic Control*

[6] K. Astrom and J. Hagglund, "PID controllers: Theory, Design and Tuning", 2nd Edition.

[7] J. Zhang, N. Wang and S. Wang, "A developed method of tuning PID controllers with fuzzy rules for integrating process," *Proceedings of the American Control Conference, Boston,* 2004, pp. 1109-1114.

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