ISSN (Online): 2456-0448
International Journal Of Innovative Research In Management, Engineering And Technology
Vol. 2, Issue 6, June 2017

Dynamic Simulation Of Transient Heat Conduction With Constant Heat Flux

[1] Manoj Prabagar. S, [2]Rajasekar. S, [3] Meyyappan. N
[1] [2] [3]Department Of Chemical Engineering Sri Venkateswara College Of Engineering,TamilNadu, India.

Abstract: ***This paper deals with the control dynamics of transient heat conduction with constant heat flux in a copper rod using simulation tool. The transfer function is taken as first order system plus dead time (FOPDT). The effect of step change in the controller is analysed and it is also observed that the oscillations was decreased and the steady state value reached in a faster rate. For any system the temperature needs to be accurately regulated to control the downstream processing's. Steady state and dynamic simulation of a copper rod, with constant heat flux has been studied and the simulation results for step change in the transient heat conduction with constant flux have been discussed.***

Keywords— FOPDT, step change, steady state

I. INTRODUCTION

Conduction is the transfer of energy in the form of heat or electricity from particle to particle without net displacement of the particle. Heat conduction is said to be in unsteady state, when the temperature at a given position varies with respect to time. It is used in the quenching of billets, annealing of solids, manufacturing of glasses, burning of bricks, steaming of wood etc. Here heat transfer plays a very important role as the rate of reaction increases with small increase in temperature. In normal conditions, during some period temperature changes in time at any place within an object, the energy flow mode is termed as transient conduction. A copper rod is used for the heat conduction. It consists of holes where the thermometer can be inserted to know the temperature of copper rod, the experiment was carried out and the transfer function was derived for transient heat conduction with constant heat flux. The simulation was done using a Proportional Integral Derivative (PID) controller and the results were shown.

II. PID CONTROLLER:

The process with an overshoot and considerable delay time gives an inverse response if there is no control to the process. The control is said to be poor when there is a large deviation from normal data. [1] The problems of overshoot, delay time and inverse response are removed considerably and are controlled in the on-going process if the PID controller is being implemented [2]. PID controller has been undeniably the most widely controller for many decades. A survey conducted shows that the ratio of applications of PID control, conventional advanced control and model predictive control is about 100:10:1. [3] The reliability of PID controllers is because they perform wide mode of processes. These PID controllers are very simple to use, tune and understand and robust in control. Most industries accept PID controller as a common control algorithm [4]. Many sufficient approaches for the determining the tuning of the parameters on appropriate PID controllers have been given in the literature in both time and frequency domain [5]. The control laws are very simple and easy to operate which makes it a highly dominated controller. [6] Model can be defined as abstract description of any type that captures the useful relevant features of a process [7]. The different things can be defined through a modelling, from the extraction of simple features of a transient response to the development of a traditional control model in terms of a transfer function or impulse response. The model for this experiment was derived in such a manner and it was simulated in MATLAB by using a PID controller which was tuned by using Cohen-Coon tuning rules.

III. EXPERIMENTAL SETUP:

The experiment setup consists of ammeter, voltmeter, copper rod, thermometer, outlet and inlet tube for cold water flow. The power supply is switched ON. The voltage is set constant as 100V in the voltmeter and the current is set constant as 0.15A in the ammeter. The temperature is noted at 5 minutes interval in the thermometer. The constant temperature is maintained by circulating cold water. The constant heat flux is maintained by passing current through a filament by maintaining a constant power input and stop watch. The temperature is noted at every 5 minutes till the steady state is reached.

Fig. 1: Experimental setup for Transient Heat Conduction With Constant Heat Flux

RESULTS AND DISCUSSION:

THE SYSTEM CAN BE REPRESENTED BY FIRST ORDER SYSTEM PLUS DEAD TIME (FOPDT):

$$G(s) = \frac{ke^{-\tau Ds}}{(\tau s + 1)}$$

WHERE,

G(s) Transfer function
D Transport delay, (s)
k Process gain, (k.s.kg-1)
τ Time constant, (s)

The following table shows the temperature change at constant interval of time.

TABLE 1: TEMPERATURE CHANGE AT THE CONSTANT TIME INTERVAL

S.NO	TIME (sec)	TEMPERATURE (^{o}C)
1	300	34
2	600	34
3	900	34.1
4	1200	34.2
5	1500	34.2
6	1800	34.2
7	2100	34.2
8	2400	34.2
9	2700	34.4
10	3000	35
11	3300	35
12	3600	35
13	3900	35
14	4200	35

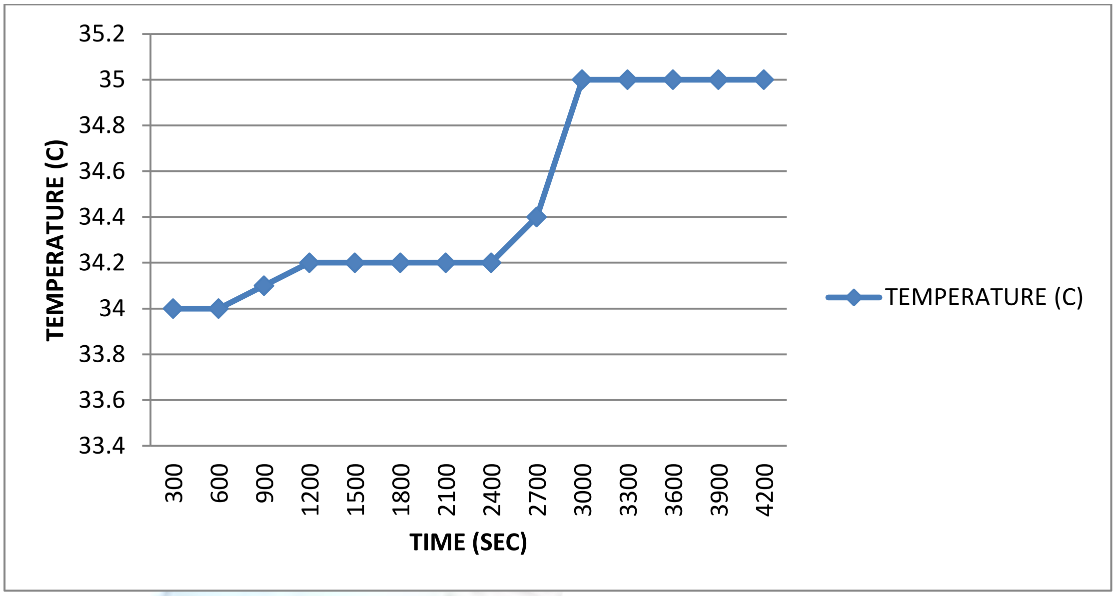

Fig. 2: Temperature response for every 5 minutes

A closed loop system was developed for transient heat conduction in a copper rod with constant heat flux. The initial tuning constants are K_C, τ_I, τ_D for PID controller were found using empirical method (Cohen-Coon method). The graph was drawn between time and temperature and the steady state was drawn. The steady state was reached at 35^0C.

TABLE 2: DERIVED VALUES OF PROCESS PARAMETERS OF THE TRANSIENT HEAT CONDUCTION IN COPPER ROD

Transfer function	$\frac{2}{22.12s+1}e^{-0.5s}$
Time delay	***0.5***
K_C	***11.797***
τ_I	***10.80***
τ_D	***0.0136***

Where,

K_C Controller gain
τ_I Integral time of controller
τ_D Derivative time of controller

The response of temperature change using step change in transient heat conduction is shown in fig. 2. A process reaction curve was used to find the parameters.

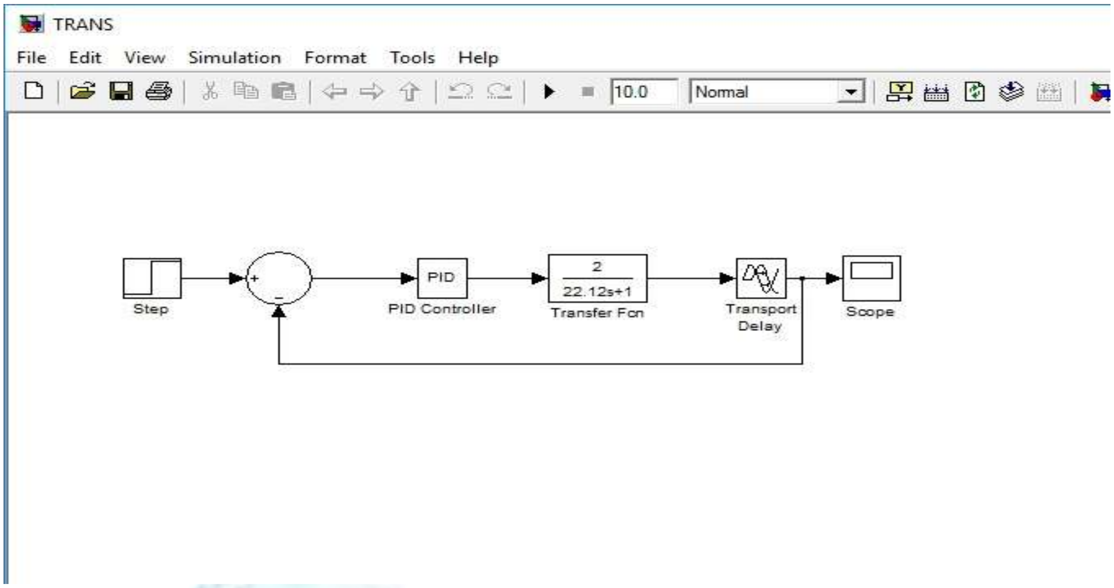

Fig. 3: – Block Diagram of closed loop system for Transient Heat Conduction With Constant Heat Flux

The above figure shows the block diagram of closed loop system for transient heat conduction in copper rod. The parameters were used in above simulink model to get the steady state response of transient heat conduction in copper rod.

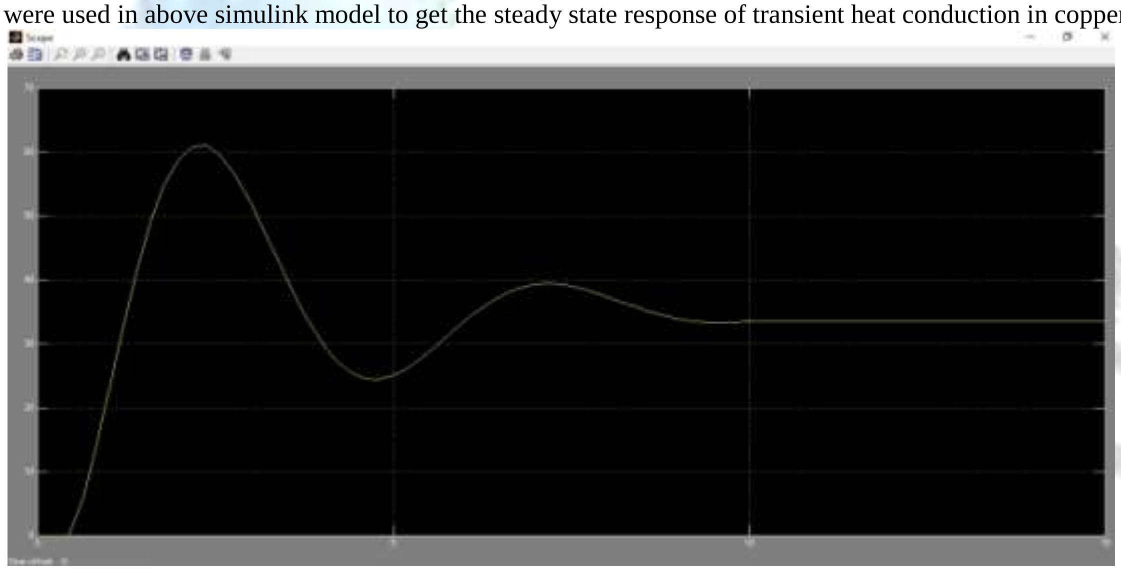

Fig. 4: Response of closed loop for Transient Heat Conduction With Constant Heat Flux using PID Controller

PID controller was used to remove the offset and the time required for the response curve to reach steady state contains no offset from the above fig.4. A stability of closed loop response using bode diagram was also studied and it indicates in fig.5 the system is stable as gain and phase margin are positive. The steady state was obtained faster in PID controller than the system that has no controller.

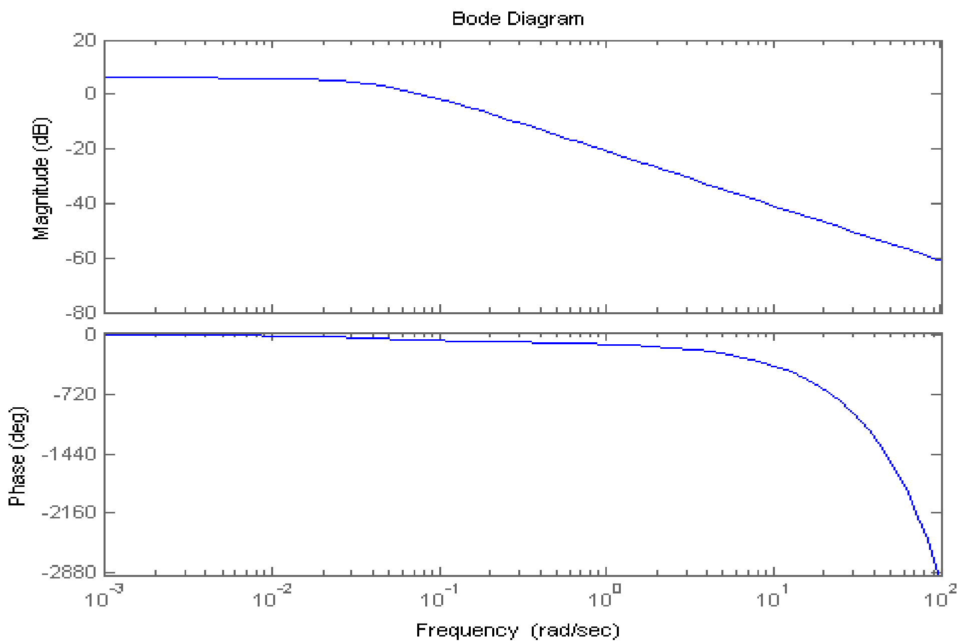

Fig. 5: Bode Diagram of open loop system for Transient Heat Conduction With Constant Heat Flux

The bode plot was obtained for the system. The above figure shows that the system is stable as said above and it indicates that the gain and phase margin are positive.

IV. CONCLUSION:

Steady state and transient response of transient heat conduction with constant heat flux using PID controller in Simulink model using MATLAB has been studied for constant time intervals. The simulation results show that the temperature change will reach steady state faster when PID controller is used. Model which is developed for transient response of transient heat conduction has been validated with bode stability plot. The process stability is analyzed with bode plot results. The results show that the system is stable for given step change in transient heat conduction as gain margin and phase margin are positive. Hence, the model which is developed for transient heat conduction with constant heat flux in copper rod can be considered for further studies.

REFERENCES:

1. Shardt, Y. A. W., Zhao, Y., Qi, F., Lee, K., Yu, X., Huang, B., & Shah, S. Determining the state of a process control system: Current trends and future challenges. The Canadian Journal of Chemical Engineering, 90, 217–245.2012.
2. Asoka, R. G., Aishwarya, N., Rajasekar. S., Meyyapan. N., SSRG International Journal of Chemical Engineering Research (SSRG-IJCER) – volume 4 Issue1 January to February 2017
3. Shamsuzzoha, M.,. Closed-loop PI/PID Controller Tuning for Stable and Integrating Process with Time Delay. Ind. Eng. Chem. Res. 52, 12973-12992. 2013
4. D.B. Santosh Kumar, R. Padma Sree. Tuning of IMC based PID controllers for integrating systems with time delay. ISA Transactions (2016)
5. Maâmar B, Rachid M. IMC-PID-fractional-order-filter controllers design for integer order systems. ISA Transactions (2014)
6. Åström, K. J., & Hägglund, T.. Advanced PID control Research Triangle Park, NC: ISA-The Instrumentation, Systems, and Automation Society. (2006)
7. K.J. Astrom, T. Hagglund, C.C. Hang and W.K. Ho., “Automatic Tuning and Adaptation for PID Controllers - A Survey”, Control Eng. Practice, Vol. 1, No. 4, pp. 699-714, 1993.