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Design of PI, PID and Fuzzy Controllers for Spiral Type Heat Exchanger

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ABSTRACT

Spiral types Heat Exchanger (SHE) are compact, single channel design used in the heating of fluids. This study concentrates on controlling a spiral type heat exchanger (SHE) using PI, PID and Fuzzy controller. The flow rate and temperature (hot side and cold side) was obtained by conducting experiment on spiral type heat exchanger. The transfer function for the system was generated using the system identification toolbox in MATLAB. Using the transfer function, PI, PID and Fuzzy controller was designed to provide a better control action.

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INTRODUCTION

A heat exchanger is a equipment used to transfer heat between one or more fluids. The fluids can be separated by a solid wall to evade mixing or they may be in direct contact. Development of design techniques for a heat exchanger with reduced cost is a dynamic job. Heat exchangers are widely used in process industries and there are many diverse types of equipment engaged for transferring heat. Optimal design of heat exchangers can be usually separated into two types: design with fixed allowable pressure drops and complete optimal design. Most of the industrial loops are controlled by PID controllers due to their simple assembly, near optimal presentation and robustness, applicability over wide range and simplicity in employment and maintenance on analogy or digital platform. Controllers are used in many processes as it improves steady state accuracy by decreasing the steady state errors and increasing the stability of the system. They also help in reducing the offsets produced in the system. Controllers controls Maximum overshoot of the system and also help in reducing the noise signals produced in the system. Here PI, PID and FUZZY controller are used.

Spiral type Heat exchanger:

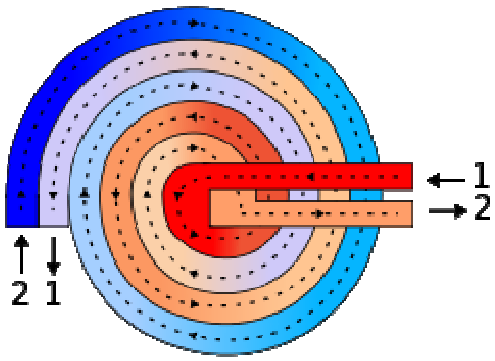

Fig. 1: Schematic Diagram of Spiral-heat-exchanger

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Spiral Heat Exchangers is a modification to the perpendicular flow of the typical helical-coil heat exchanger (HCHE) involves the spare of shell with another coiled tube, allowing the two fluids to flow parallel to one another, and which requires the use of dissimilar design calculations, which may refer to a helical (coiled) tube configuration, the term refers to a couple of flat surfaces that are spiral to form the two networks in a counter-flow arrangement. Each of the two networks has one long curled path. A couple of fluid ports are linked tangentially to the outer arms of the spiral, and axial ports are common, but non-compulsory. The SHE is noble for applications such as pasteurization, digester heating, heat regaining, pre-heating and effluent cooling. For slush treatment, SHEs are usually smaller than other types of heat exchangers. The foremost advantage of the SHE is its highly effective use of space. This characteristic is frequently leveraged and partially reallocated to increase other improvements in performance, according to well known alterations in heat exchanger design.

System Identification:

System identification tool box is used to obtain the transfer function which is used to construct models from input and output data. The model obtained from this method describes the performance of the process around an operating point. When a priori knowledge on the characteristics of the unknown system is available, the identification procedure can be improved. The system identification procedure has a natural logic flow. First collect the data and choose a model set then pick up the best model in these set after arriving a particular model (i.e. the one in set that best describes the data according to chosen criterion it than remains to test whether this model is good enough)..

PI Controller:

The Proportional-Integral (PI) algorithm calculates and transmits a controller output signal for every sample time, T, to the final control element. The PI algorithm is influenced by the controller tuning parameters and the error, e(t). PI controller is mainly used to reduce the steady state error resulting from Proportional controller. It has a negative impact on speed of the response and overall stability of the system. This controller is mostly used in areas where speed of the system is not an problem. Since Proportional controller has no ability to predict the future errors of the system it cannot reduction the rise time and eliminate the oscillations, proportional plus integral controller is preferred. PI Controller is a device which consists of two terms that produce an output signal .One term is proportional to input signal and other term is proportional to the integral of input signal. PI controller is simple, low cost and easy to design. Integral action eliminate offset, increases the loop gain and makes system less sensitive to parameter variations.

$P(\text{proportional}) = K_P\, e(t)$

$I(\text{integral}) = K_i \int_0^t e(t)d(t)$

PI controller output, $U(t)= K_P\, e(t) + K_i \int_0^t e(t)d(t)$

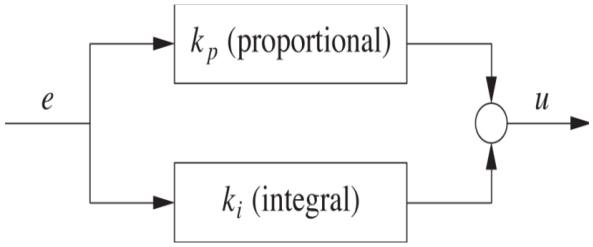

Fig. 2: Block diagram of PI controller

PI controller output, $U(t)= K_P\, e(t) + K_i \int_0^t e(t)d(t)$

Table I: PI Controller parameters

PI controller	K_P	K_i
	54.179	34.2279

PID Controller:

A PID is a control loop feedback mechanism widely used in industrial control system. The fig .3 shows a PID controller. A PID controller calculates the ‘error ‘values at the difference between a measured process variables and the desired set point The controller attempts to minimize the error by the adjusting the process control outputs. PID controllers are widely used in many industries because of it combine the advantages of proportional, derivative and integral control action. The reason PID controllers are so popular is that using PID gives the designer a larger number of options and those options mean that there are more prospects for changing the dynamics of the system in a way that helps the designer. It makes the system less sensitive

to parameter variations (P mode),reduces the steady state error without manual reset(I mode) and improves stability of the system and The Derivative term provide faster response of the system (D mode)

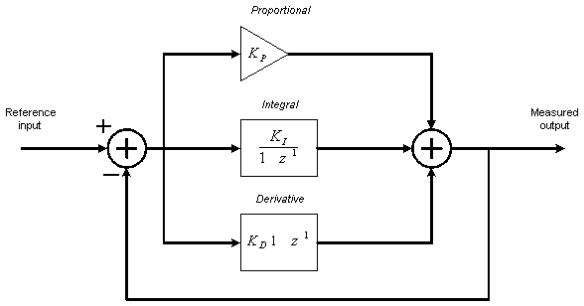

Fig. 3: Block diagram of PID controller

PID controller output, $U(t)= K_P e(t) + K_i\int_0^t e(t)d(t)+ K_d \frac{d(e)}{d(t)}$

Error = SP – PV

t- time or instantaneous time

Table II: PID Controller parameters

PID controller	K_P	K_i	K_d
	80.4554	66.109	14.561622

Fuzzy Controller:

A fuzzy control system is a control system constructed based on fuzzy logic .A mathematical system that analyses analog input standards in terms of logical variables that yield on continuous values between 0 and 1, in difference to classical or digital logic, which functions on discrete values of either 1 or 0 (true or false, respectively).The fuzzy logic controller offers an algorithm, which modifications the expert knowledge into an programmed control approach.. The fuzzy control schemes are rule-based systems in which a set of fuzzy rules characterise a control decision mechanism to correct the effects of certain structure stimuli. With an effective rule base,. The rule base of fuzzy logic reveals the human expert knowledge, stated as linguistic variables, while the membership functions denote skilful description of those variables. This research paper considers a spiral type heat exchanger and builds a SISO model of the system with the help of experimental data offered. This system also takes in to account different disturbance elements and transportation delay. Fuzzy identification aims at discover a set of fuzzy IF-THEN rules with well-defined parameters that can describe the given input/output performance of the process. A dynamic fuzzy model of the physical plant is first resultant from input and output capacities using a fuzzy clustering technique. The designed fuzzy logic controller for the heat exchanger system is then compared with a PI and PID Controller.

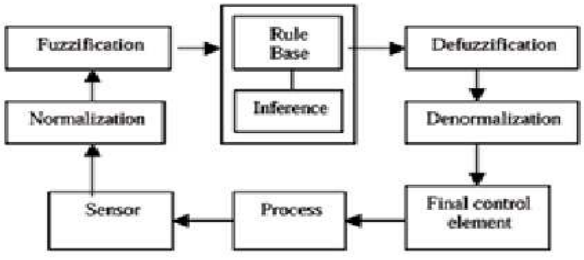

Fig. 4: Fuzzy control block diagram

RESULTS AND DISCUSSIONS

A simple first order based PI, PID and Fuzzy designed technique is proposed for processes. The transfer function obtained using MATLAB is used to design a controller for heat exchanger. Results of the analysis show that the present method is able to deliver overall closed-loop stability. This design method is very simple to implement.

$G_P(s) = \frac{K_p}{1+ T_p S}$

K_p = 0.80137

T_p = 16.804

$$G_P(s) = \frac{0.80137}{1+ 16.804\ S}$$

Table III: Comparison of Different Parameters in Controllers

CONTROLLER	Rise Time	Maximum Overshoot	Settling Time	IAE
Fuzzy	0.69	0.9959	0.996	0.2203
PID	1.05	1.11	1	0.3796
PI	2	2.5	1	2.028

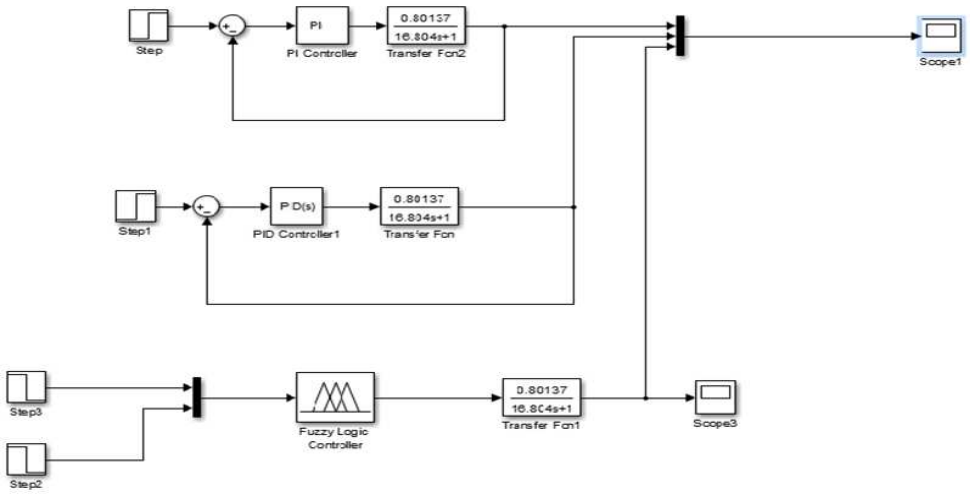

Fig. 5: Block diagram of PI, PID and fuzzy controller

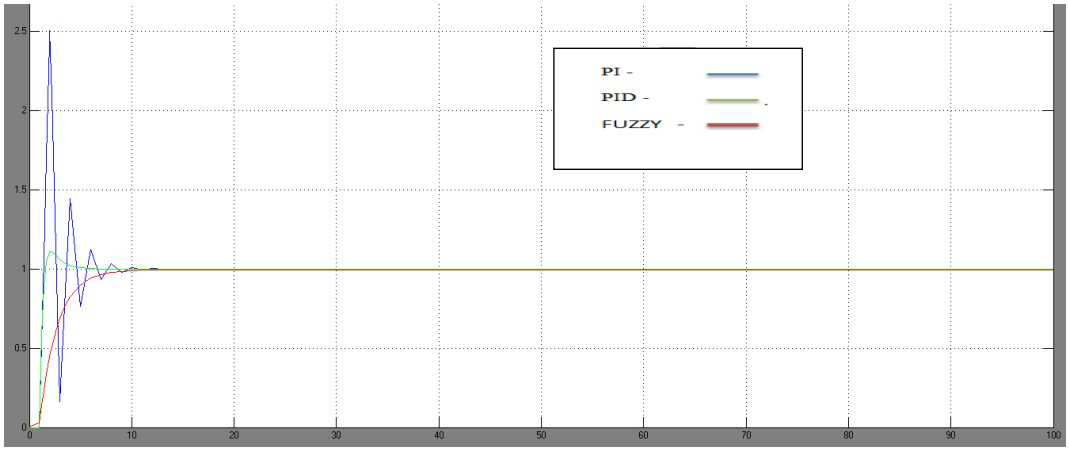

Fig. 6: Controller Response of PI, PID and FUZZY controller

Conclusion:

The design of controller for the spiral type heat exchanger was studied. On comparing PI,PID and Fuzzy controller, PID controller shows better performance compare to PI controller because minimum number of oscillations were obtained in the PID controller. Fuzzy controller also improves steady state accuracy by decreasing the steady state error and increases the stability of the system.

REFERENCES

Ahmed Maidi, 2008. "Optimal linear PI fuzzy controller design of a heat exchanger" Elsevier, Chemical Engineering and Processing, 47: 938-945.

Kokate, R.D. 2009. "IMC-PID and Predictive Controller Design For a Shell and Tube Heat Exchanger" Second International Conference on Emerging Trends in Engineering and Technology, ICETET-09 978-0-7695-3884-6/09 $26.00 © 2009 IEEE

Martina Maggio, 2008. "Optimal linear PI fuzzy controller design of a heat exchanger" Elsevier, Chemical Engineering and Processing, 47: 938-945.

Rajni Jain, 2011. "Design of self tuning fuzzy controllers for nonlinear systems" Elsevier, Expert Systems with Applications, 38: 4466-4476.

Rodrigo Rodrigues Sumar, 2010. "Computational intelligence approach to PID

controller design using the universal model "Elsevier, Information Sciences, 180: 3980-3991.

Santos, M., 2002. "Control of a cryogenic process using a fuzzy PID scheduler" Elsevier, Control Engineering Practice, 10: 1147-1152.

Shinskey, F.G., 2001. "PID-deadtime control of distributed processes" Elsevier, Control Engineering Practice, 9: 1177-1183.

Vijayan, V., 2012. "Design of PID controllers in double feedback loops for SISO systems with set-point filters" ISA Transactions, 51: 514–521.

Yuvraj Bhushan Khare, 2010. "PID Control of Heat Exchanger System" International Journal of Computer Applications (0975 – 8887), 8(6).