Control the Temperature of Hot Air Blower Rig using PI (Proportional Integral) and Adaptive PI Controllers

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Abstract: Nowadays, control system is considered central part in the development and upgrading of new evolution and technology. Almost, every single part of our daily recital is involved by several types of control system. By changing temperature can change the performance and characteristics of any process. In process industry, temperature control of different systems is usually required as reactions rates are controlled by heating and cooling the reactants. For industrial applications, automatic temperature control of furnaces is required for melting, decomposing and studying the physical and chemical properties of substances. Temperature control is one of the vital control variables like flow, level, pressure and motor speed. In industry, a fine control of temperature can be a critical issue with consideration of safety of the equipment as temperature control systems are generally non-linear in nature; such systems are controlled by both linear and nonlinear controllers. Linear controllers are easy to design but their performance cannot be very good. In this research we used Linear PI controller for controlling the actual data(temperature) of hot air blower rig at different operating points with different voltages using linear system which shows good correlation between actual data and achieved results.

Keywords: PI controller, temperature control, linear and non-linear controller, Hot air blower

I. INTRODUCTION

In control system engineering, the ability to accurately control the system that involves the temperature of flowing air is vital to numerous design efforts [1]. Hot air blower plays in an important role in the industry. In order to increase safety, quality and reduce cost, developing controllers for the current system will benefit the industry and also the environment. So the focus in design area is to avoid overshoot in temperature and shorter the rise time. A Linear PI controller is a good solution which is one of most popular controller in the industry Adaptive controllers are also useful for temperature control applications but they need higher computations... Adaptive PI controllers can also be used for such situations but they require higher number of computations due to complexity of the adaptive algorithms [2]. An alternative solution for temperature control problem is to use a number of PI controllers for different operating points. Each PI controller must be tuned in such a way that it gives the required performance objectives in those points. . Adaptive control is a method which involves adapting the control law used by a controller to deal with the reality that the parameters of the system being controlled are time varying, nonlinear or somewhat uncertain [3]. PI control is the favourite technique of control for HVAC systems because of the improvements in accuracy and energy consumption when match to proportional control [4].

In this research we used the process trainers PT 326 for hot air blower rig; it is basically self-contained controller and process equipment which consists of heater element, motor element, conditioning, amplifying circuitry, sensor and analogue temperature scale. The detail description of this system can be found in its User's Manual [5]. This system has facility of proportional and two step controllers, which have performance limitations. In this research we discussed static and dynamic characteristics. Static characteristics helped to check out system behaviour if the system is linear or non linear. After first set of investigations we found that system is linear so we worked on transfer functions using dynamic characteristics. Details of transfer function and first set of investigation is given in following sections. Aim of this research is to designed a PI Controller for different operating points (various voltage values) using adaptive PI Controller. For experimental purposes, we introduced output delays, actuator and sensor constraints and disturbance. Input and output terminals are also accessible for external control.

II. METHODLOGY

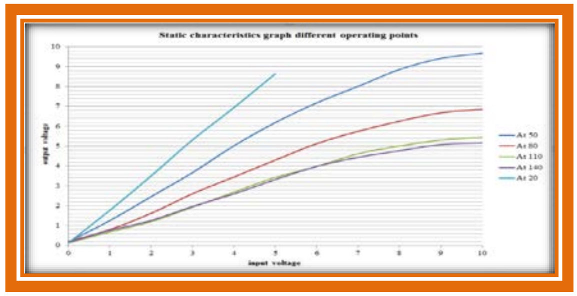
The control of Hot Air Blower rig depends on various steps, initially checked the behaviour of system, is it linear or non-linear by static characteristics, and drew the graph between input and output voltages of process trainer PT 326.Figure 1 shows that our system is Linear, then checked the dynamics of system, for check the dynamic characteristics of system, designed a data collect air model for process trainer PT 326 , where data collect air model is connected to hot air rig via computer through PCI–DAS 1002 input/output board in such a way that connected analogue output to DAC 0, analogue input to channel 1 and ground is connected to ground of hardware interference and we used step time of 0.05 second in our models. After initial assembly data file is connected to target in the software and program was run for first time. On the other hand designed a servo fit model using suitable transfer function which output best fit on data collect air model output. In third step design a Linear PI Controller for data collect and servo fit model. In servo fit model designed a PI controller using previous transfer function which chose for dynamic characteristics. Finally designed adaptive PI Controller for data pre processing, checked single Adaptive PI controller on different operating points.

I. ANALYSIS AND RESULTS

This section shows simulation setting and results for static characteristics, dynamic characteristics, PI data collection for air model, testing of single PI controller and adaptive PI controller model. Above mentioned observations and simulation results with better fit are given in figures 1-13.

A. Static Characteristics

In first part we measured the static characteristics of a hot air blower Rig PT326, where we chose contrasting operating points using input and output voltages, and sketch graph between voltages and suitable operating points. Graph shows that, the system is a linear, because lines of graph are approximately straight on every operating point..



B. Figure 1: static characteristics input versus output graph

Input voltages (V)	Output voltages (V) at 20°c	Output voltages (V) at 50°c	Output voltages (V) at 80°c	Output voltages (V) at 110°c	Output voltages (V) at 140°c
0	0.12	0.18	0.2	0.13	0.16
1	1.77	..25	0.8	0.68	0.76
2	3.5	2.46	1.62	1.2	1.26
3	5.32	3.67	2.61	1.93	1.97
4	6.94	5.02	3.45	2.69	2.6
5	8.65	6.19	4.3	3.43	3.32
6		7.18	5.13	3.98	3.98
7		8.01	5.75	4.62	4.44
8		8.86	6.26	5.01	4.77
9		9.42	6.68	5.31	5.08
10		9.68	6.86	5.46	5.16

Table 1: Voltages at different operating points

A. Dynamic characteristics

After initial results we identified the dynamic characteristics ,for dynamic characteristics we used different transfer functions for different operating point in order to control the dynamic behaviour of hot air rig. In second part to check the dynamics of model use two Simulink models were used, in first model data of air model and rig was collected and second model was used for servo fit simulation.

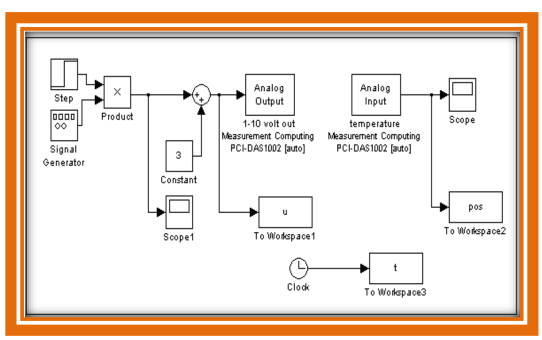


Figure 2: Data collect air model at 50°c at (2-3)

voltages

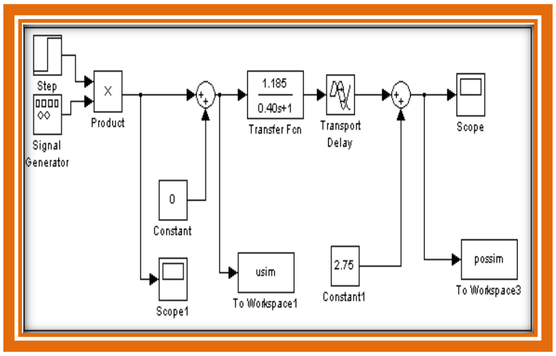


Figure 3: Servo fit model at 50°c at (2-3) voltages

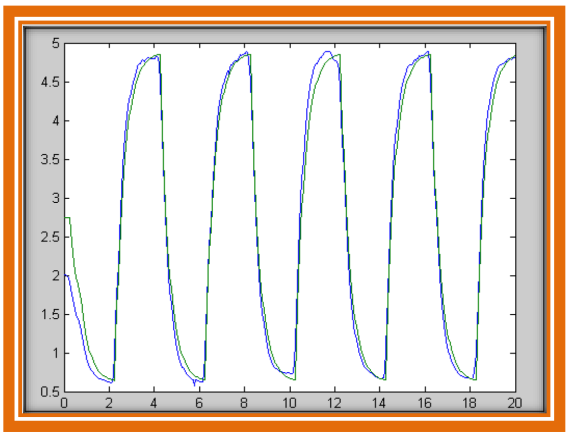


Figure 4: Graph between data collect air model and servo fit model at 50°c at(2-3) voltages

A. PI data collect air model and PI servo fit model at50°c at (2-3) voltages

In third part methods for collecting data are discussed where data collect air model is connected to hot air rig via computer through PCI–DAS 1002 input/output board in such a way that connected analogue output to DAC 0, analogue input to channel 1 and ground is connected to ground of hardware interference and we used step time of 0.05 second in our models. After initial assembly data file is connected to target in the software and program was run for first time. On the other hand parallel computing is used to run the servo fit model.

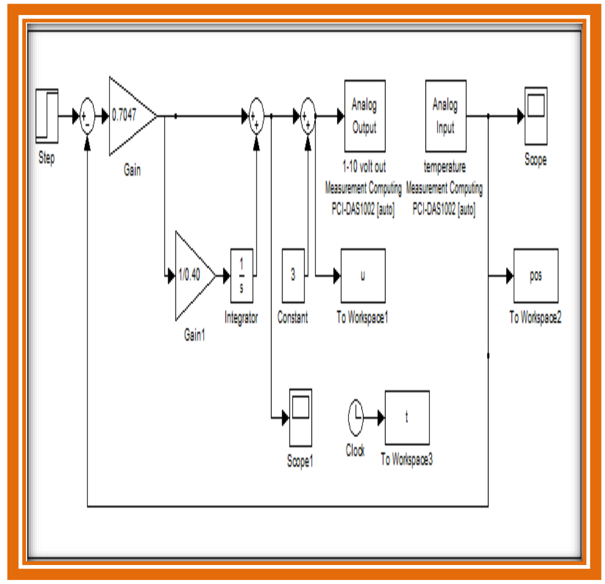


Figure 5: PI data collect air model at 50°c at (2-3) voltages

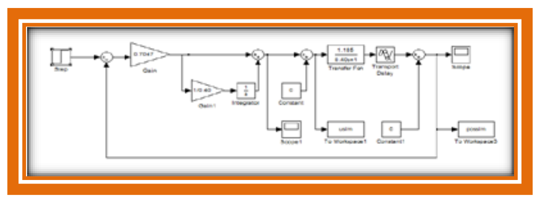


Figure 6: PI servo fit model at 50°c at (2-3) voltages

After first computation we analysed graph between data collect air model and servo fit model, compared both graph if they are not same to each other then use servo fit model and change the values of transfer function, transport delay and constant until obtained graph in which both output is same or fitted together.

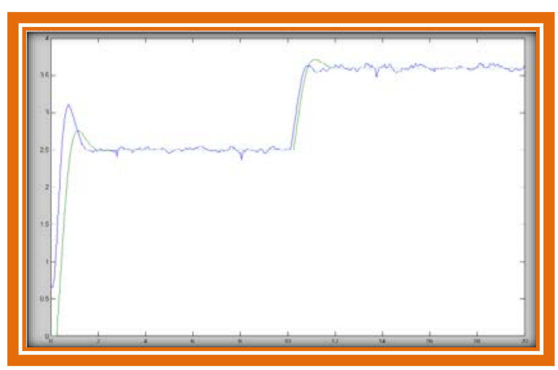


Figure 7: Graph between data collect air model and PI Servo fit model at 50°c at (2-3) voltages

Graph shows the data collect air model and servo fit model outputs fitted each other so the required models are working properly and can be used in industries. In all graphs green lines show servo fit model output and blue line illustrates data collect air model output. On remaining operating points same methods will be used to check dynamics of hot air blower rig at different operating points.

B. Testing of single PI controller at different operating points

Adaptive control generates a set of tools which present a system approach for automatic alteration of controller in real time. In sequence to obtain otherwise to keep an essential stage of control system performance when the parameter of the plant dynamic model are unidentified and/or vary in time.

For instance, the parameters of an industrial process may vary, depending on the current operating point (e.g. temperature, desired yield). The advantages of adaptive interaction are that, it does not require virtual knowledge of the plant, stability is guaranteed after convergence, and the initial system can be random. Finally the practical results for temperature output and actuator signal are shown and discussed.

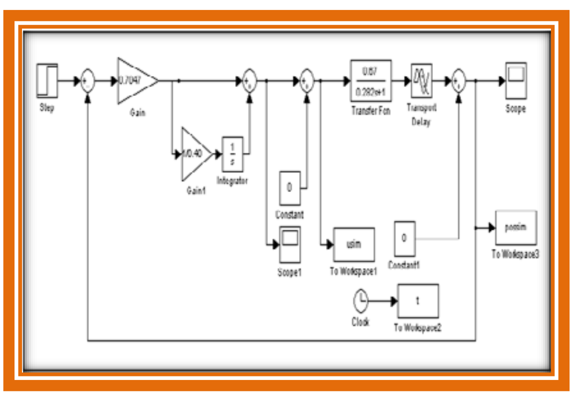


Figure 8: Check the single PI controller at different operating point, but it is not working well at different operating points and gives incorrect result. For this reason use Adaptive PI method and check single controller at different operating points.

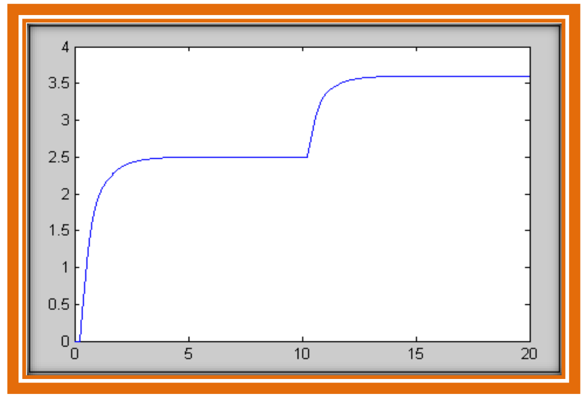


Figure 9: Servo fit model for 1st check

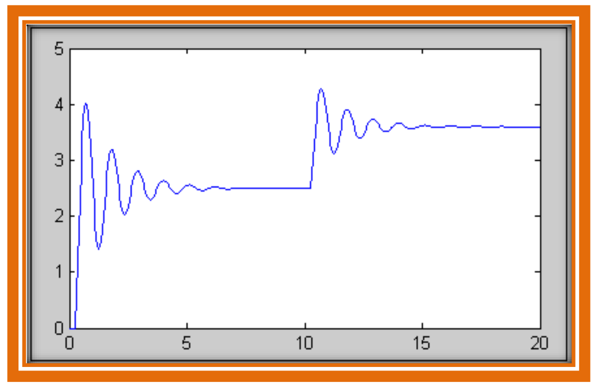


Figure 10: Servo fit model for 2nd check

C. Adaptive PI Controller model

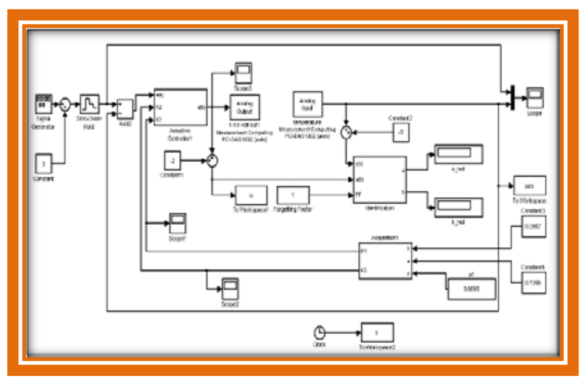


Figure 11: Adaptive PI data collect air model at 50°c at (2-3) voltages

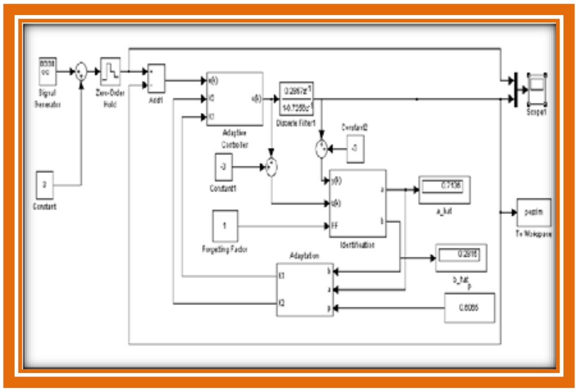


Figure 12: Adaptive PI servo fit model at 50°c at (2-3) voltages

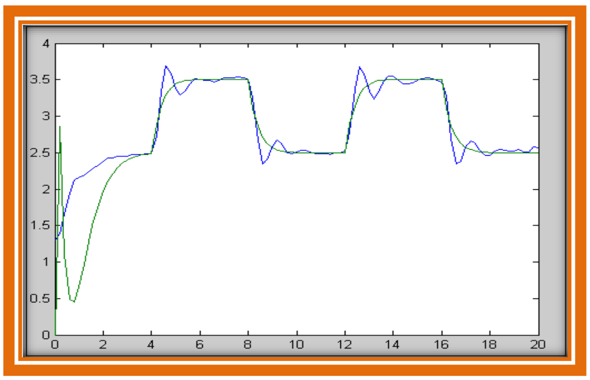


Figure 13: Graph between adaptive PI data collect air model and adaptive PI servo fit model at 50°c at (2-3) voltages

II. CONCLUSION & RECOMMENDATIONS

In this research we used PI controller for controlling the actual data (temperature) of hot air blower rig. This technique is very useful to control the temperature of any process in variety of industries as it can be easily implemented with the help of the gains of the particular controller. In this research we used controller to control the temperature of hot air blower rig at different operating points using different voltages where we achieved excellent result for all observations. We authenticated the dynamics of process before designing a Linear PI controller because if dynamic behaviour of a process is alike (data collect air model and servo fit model are fitted to each other), transfer function which is selected on the project will be more likely to be accurate .This research shows dynamics of process at different operating points using different voltages which is used in PI data collect air model. We chose these operating points with the help of static characteristics of process and draw a graph between input and output which is approximately linear, so our system is linear which can easily control compare to nonlinear systems. For data pre-process, in adaptive PI controller check the output of hot air blower rig in real time and verify it with simulated model. In future we will use adaptive PI time delay estimation to control the process.

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