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Study of the Process Effect of Pre-Heater in the Temperature

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Abstract: *In different industries such as for example, synthetic, food and petrochemical, controlling of the temperature assumes an imperative job. This assists with ensuring the effective procedure activity, creating more determination accommodating item with less waste. In this paper, the work is completed in temperature process which is constrained by SCR based voltage controller. Since it is a Non-direct procedure, the exchange capacities are acquired for different areas. The framework models are distinguished utilizing step test strategy for the temperature procedure with and without pre-warmer get together. The got models for both the procedures are approved by looking at the reactions of the distinguished exchange capacities with the first framework for a stage input. In the wake of picking the best fit model, a PID controller is intended for the equivalent. At that point the viability of pre-radiator get together to the temperature procedure is broke down.*
Key words: *PID Control, Pre-heater, SCR, System identification, Validation.*

I. Introduction

Temperature control is extremely important in most of the industries. Linear controllers can yield a satisfactory performance if the process is operated close to a nominal steady state. But when the operating point and the parameter changes, gradually the performance of the controller reduces. Advance controllers such as adaptive or predictive controller works well even if the model of the system is not matched with the original system. However the implementation and design of the controllers need the system model or the transfer function of the system. Many processes have a non-linear behavior due to non linear physical, chemical or thermodynamics effects. Such process may have the error response due to the delay occurred. Time-delays appear in many processes in industry and other fields, including economical and biological.

System Identification methods can be used to build mathematical models of dynamic systems based on observed and measured input and output data from the system. Based on the input and output relationship of the process the mathematical model is derived this is known as System Identification. The obtained mathematical model becomes the replica of the system. So when a test input is given to the model, it is same as testing the real process. This helps in enabling the safety of the process and also to design different new control algorithms. By using system identification methods the perfect steady state region is to be selected by comparing with other regions.

In this work, the effect of pre-heater to the temperature process is being analyzed. For the current study, temperature of the inlet air is maintained constant. The pre-heated air temperature is maintained at 50 C and the room temperature for non pre-heated air. After that PID controller is implemented for controlling the output temperature.

II. System Identification

The system identification is the process of obtaining the mathematical model of the original system in terms of two methods viz. Transfer function and State model [1].

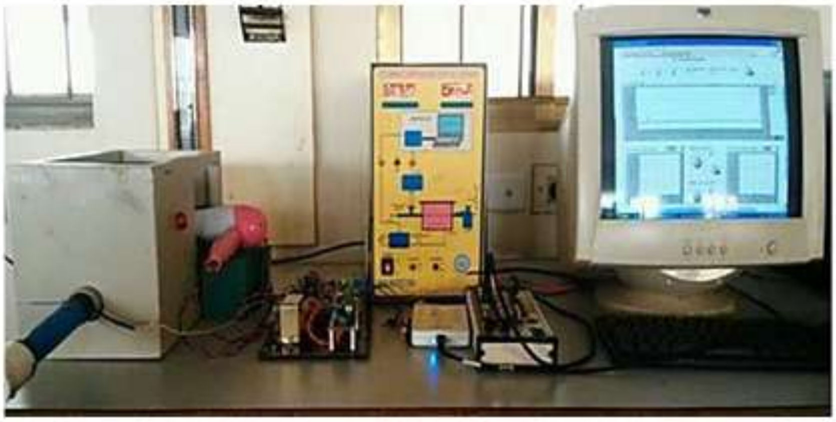

Figure 1 Hardware setup of Temperature Process with pre-heater

In this paper, the transfer function of the temperature process is obtained using process reaction curve is the conventional and commonly used method to find the transfer function of the system. Since this process is a non-linear system, the transfer functions are obtained for different regions of temperature. Here the system identification is done for the process with and without the pre-heater. The temperature process along with the pre-heater setup and its connection is shown in the figure-1. Then front panel of the LabVIEW programme for acquiring the data of the temperature process is shown in figure-2. Same programme is used for both the cases (With/without Pre-heater), but there will be a change in arrangement for those cases. Figure-3 shows the block diagram of the LabVIEW programme for identifying the processes.

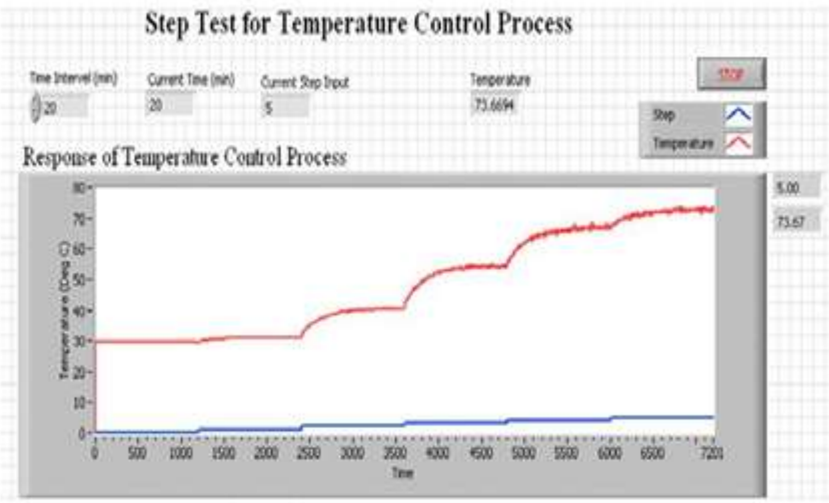

Figure 2 Front panel of the System Identification for various regions

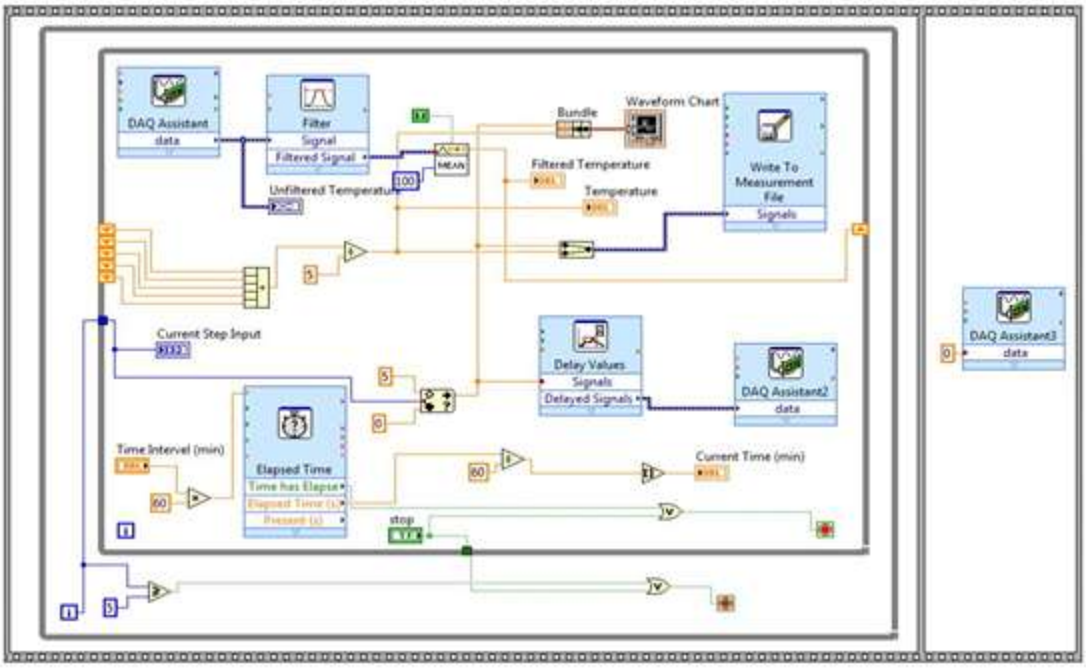

Figure 3 Block diagram for identifying the temperature process

III. Identifying Temperature Process Without Pre-Heater

The model plant consists of an oven which can be heated up to 1000^{o}C.The temperature of the oven is sensed by a K type Thermocouple [3]. The thermocouple is connected to an electronic controller [2]. The input to an electronic controller can be programmed to be any type of thermocouple or RTD or voltage. The output of the controller can be programmed to voltage or current or pulse. The output of the electronic controller is set as the current and the same is given to an SCR driver module. The driver module acts as a final control element and converts 0-2V into 0-230V AC.

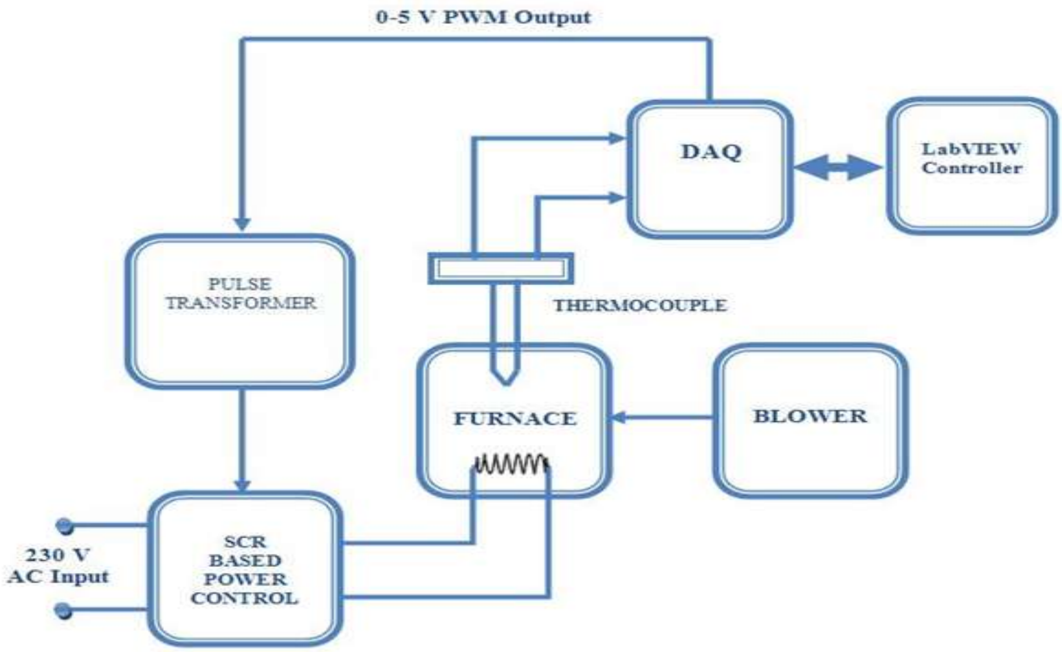

Figure 4 Block diagram without pre-heater

A 4 KW heater coil is connected to an SCR driver which heats the process and the temperature is maintained [2]. The temperature of the oven process can be monitored by the indication on the temperature indicator controller (TIC).The system has a blower which is continuously on and the air from the blower cools the plaster of Paris clay in the oven.[4].

Table 1 Transfer Functions obtained for various regions without pre-heater

Voltage Range (V)	Temperature range (C)	Transfer Function
0-1	29.5-31	$\frac{1.654}{255s+1}e^{-6s}$
1-2	31-40.5	$\frac{0.736}{214s+1}e^{-5s}$
2-3	40.5-54.5	$\frac{1.238}{213s+1}e^{-4s}$
3-4	54.5-67	$\frac{0.894}{217s+1}e^{-5s}$
4-5	67-72.5	$\frac{1.342}{184s+1}e^{-4s}$

IV. Identifying Temperature Process With Pre-Heater

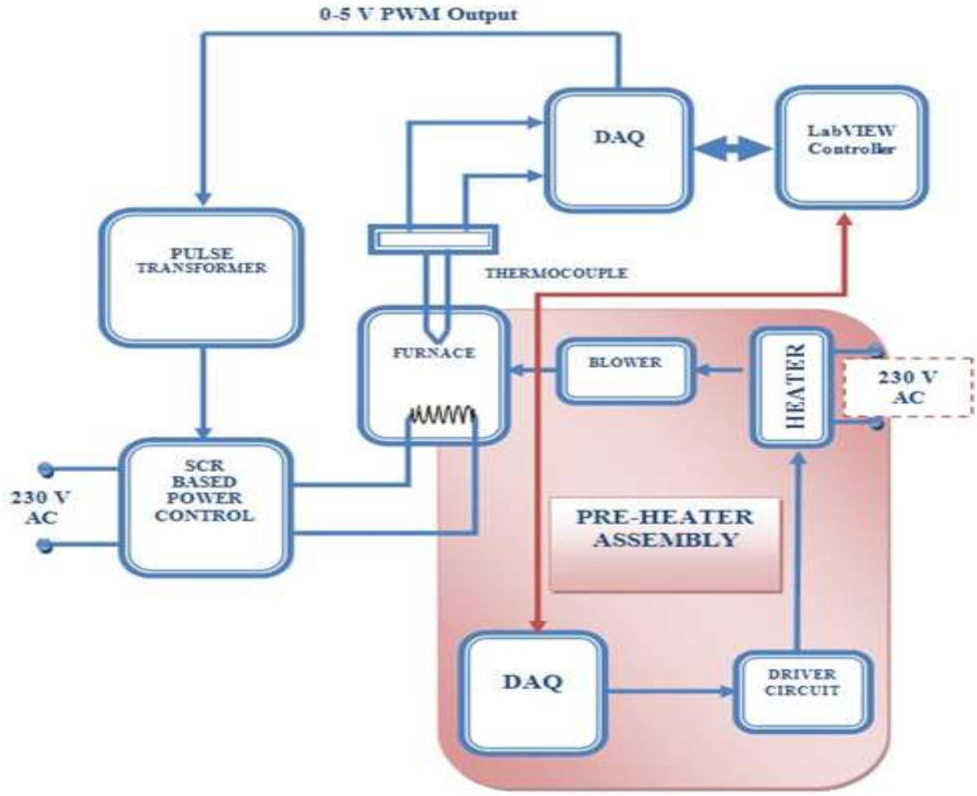

Figure 5 Block diagram of the system with pre-heater

A pre-heater assembly is introduced in this exciting system shown in figure-5, to increase the performance of the system. The pre-heater is placed near the air inlet to the blower. As the result, pre-heated air enters into the furnace. Here the temperature of the pre-heated air is maintained constant at 50 C . The transfer functions are obtained for various regions for both the systems with and without pre-heater are shown in Table-1 & 2.

Table 2 Transfer Functions obtained for various regions with pre-heater

Voltage Range (V)	**Temperature range (C)**	**Transfer function**
0-1	29.5-31.5	$\frac{1.243}{255s + 1} e^{-2s}$
1-2	31.5-42.4	$\frac{0.789}{214s + 1} e^{-3s}$
2-3	42.4-52.3	$\frac{0.827}{213s + 1} e^{-2s}$
3-4	52.3-65.6	$\frac{1.898}{225s + 1} e^{-3s}$
4-5	65.6-71.3	$\frac{1.528}{184s + 1} e^{-2s}$

V. System Validation

The system is validated by comparing transfer functions with the original system. The step input is given to the transfer function and to the real process at the same time. The graphs are compared and best fit model is obtained using the simulation tool. Figure-6 shows the output of the validated best fit model. From the output, it is inferred that the transfer function in the forth region in the system identification gives the best fit compared to the other regions. So that particular transfer function is considered for further study.

By comparing the five regions of transfer functions in step testing method, the fourth region of transfer function matches the most with the process in the both the cases of with & without pre-heater which are listed below.

Without Pre-heater : $G_4(s) = \frac{0.894}{217s + 1} e^{-5s}$; With Pre-heater: $G_4(s) = \frac{1.898}{225s + 1} e^{-3s}$

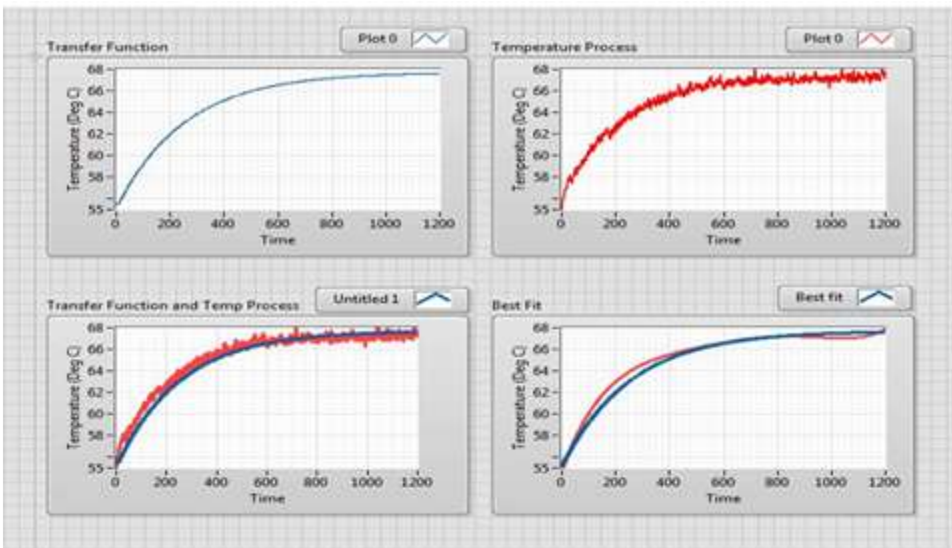

Figure 6 Output of the best fit transfer function

VI. Simulation Results

The Conventional PID controller is designed for the best fit transfer function i.e., the forth region. Using the simulink in the MATLAB software, the response of the system without pre-heater is obtained. In the similar way, the PID controller is designed for the both the cases.

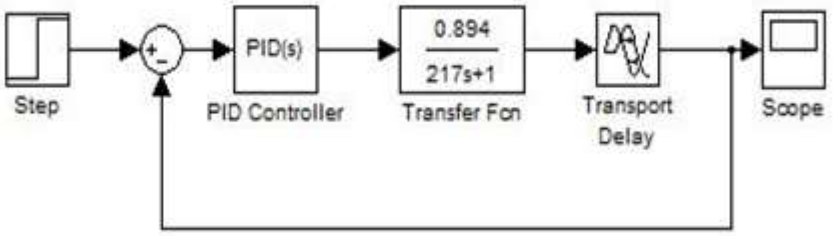

Figure 7 MATLAB program using PID controller without pre-heater

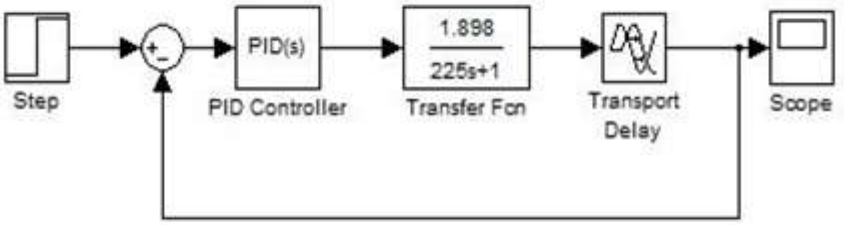

Figure 8 MATLAB program using PID controller with pre-heater

The PID controller is designed using the Cohen-Coon Method [6]. The Proportional, Integral and Derivative constants are found using the formula table of Cohen-Coon method and are substituted in the PID Controller block. The time domain performance analysis is done for both the systems and the outputs are tabulated. From the values of the rise time, peak overshoot & settling time, the performance of the process is determined. Table-3 shows the performance of both the temperature process with & without pre-heater assembly.

Table 3 Comparative study of the response of the system with and without Pre-heater

S.No	**Without Pre-heater**	**With Pre-heater**
Rise Time (Sec)	90.4	83.8
Overshoot %	4.6059	2.782
Settling Time (Sec)	162	110.5

VII. Conclusions

The comparative study has been made and it is inferred that the system with pre-heater assembly shows a better response compared to the process without pre-heater. The rise time, overshoot and settling time has been reduced with the effect of pre-heater. In this study, the pre-heated air temperature is kept constant. In future, even the temperature of the inlet air will be controlled by pre-heater assembly to attain faster settling time and less overshoot.

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