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Comparative Analysis of Temperature Control for Different Applications

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***Abstract*—Temperature Control Application is often required in industries. In this paper a low cost application for temperature control in a dyeing system using the PIC16F1939 was designed and developed. This study includes comparison of real time temperature control implemented on a microcontroller for Ventilation, DC motor and Dyeing.**

***Index Terms*—Dyeing, DC Motor, Gradient, Hold Time, Temperature Control, Ventilation.**

I. INTRODUCTION

In industries temperature control is required for various reasons like ventilation, water heating and cooling, dyeing process, etc. As temperature control system becomes better, the overall system becomes more efficient. Temperature control thus becomes an important parameter in various systems. For example of application in the production of a variety of drink products such as chocolate drink, strawberry milk produces etc. and the example of process industries which uses it are Nestle, Yeoh Hiop Seng, F&N, etc. Therefore the concept of different controller for control problem has been developed into a popular research topic in recent years [3].

There are different controllers which we can use to make the temperature controller, for example Microcontroller 8051, now days very commonly used PIC, PI, PID controllers, etc can be used. There are many types of devices available which can sense temperature we can say thermistor, thermocouple, RTD. Temperature sensors are also available now days which can be used directly.

Temperature control is needed because of some reasons say because of the temperature change developed by the machines in the environment by undergoing their heating as well as cooling process. The heat transfer used in the process can be complex and uneven so temperature control is required. As well as in some application the measurement required must be exact. There ae many industries that require Temperature control like Metal industries the extraction of metal takes place at a very high temperature. Making of Pottery, Glass, Brick, Cement, Etc they all take place at a very high temperature. Foods they required to be stored at different temperature, they need to be boiled, cooked at various temperatures so temperature control is needed. In most of the factories the boilers are required to produce steam as the steam is required for different process so the use of temperature control is again required.

The temperature range on the places where life can survive is -60^0 to $+60^0$ C. Man can survive temperature of 20^0 C. So we say that the temperature is basically wide ranged and it should be controlled in industries to get some specific output. Heat is used in all the factories now days and their control has become necessary, here we have compared Temperature controller which are manufactured by different processes.

II. TEMPERATURE CONTROL FOR VENTILATION

In paper [1] the author focuses on the model identification and control of temperature in a test room designed for a ventilation system. The goal of this study is to analyze and develop an educational plant that can be used at different applications. The author used PIC18F4620 for this study. Plant implementation can easily be reused by users who are not expert in plant design. The laboratory architecture proposed in this paper permits to run experiments while interacting with its components

The study is dedicated to the educational activities in the field of control system design. The general purpose of the process is to ensure a desired temperature in a closed loop safety operational functionality and for understanding the dynamics of a cooling system. Moreover, the designed plant is a low cost application with components ease of access. The plant consists in a cooler, a resistance, a sensor and a microcontroller that are encapsulated in a small testing room.

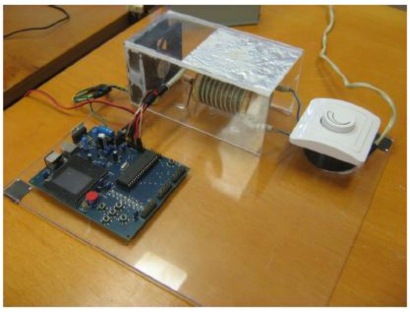

Fig. 1 – Low cost implementation of the cooling system.

To relieve the performance of the proposed cooling system it is necessary to increase the test room temperature with an electrical heat resistor made of nickel. The heat discharge in the small test room will be fixed by limiting the value of the current with a variable voltage actuator for alternative current. The function of the cooler will be to decrease the air temperature from the test room.

The microcontroller will send a signal to L298 an H-bridge, who will command the DC motor of the cooler. The heat resistor is made by nickel and emits a heat quantity in the environment. To avoid a high temperature degree, the current range of the resistor is limited by a voltage potentiometer to obtain a 77^{o}C in the conceived test room. This part of the system used a 220 V external source. The motor speed is varying from 950 to 3600 rotation/min offering a maximum 44.3 CMF airflow.

The LM335 analog sensor is a useful transducer for the system. The sensor operates form -40oC to 100oC and in this application is used the plastic TO-92 packages sensor, considering basic temperature. The proposed development board contains the PIC 18F4620 which can significantly reduce power consumption during operation.

The communication to the computer is made with a USB cable which adapts the signal to serial communication with a hardware device FT232RL.

The system is linear, discrete-time and single input-single output. The input signal considered is the duty cycle of the PWM signal and the output is represented by the air temperature value measured from the LM335 analog sensor.

III. TEMPERATURE CONTROL FOR ELECTROMAGNETIC OVEN

In paper [2] the author makes an effort to control the speed of the DC motor and figure out the design process of a PID temperature controlling system of the electromagnetic oven using LabVIEW software. This paper is to design PID controller to supervise and control the speed response of the DC motor with the virtual instrument graphic monitor software LabVIEW and also describes a simulation that involves designing, building, and demonstrating a regulatory control system. There are many algorithms/methods proposed in literature for tuning of PID controller such as Process reaction curve, Ziegler Nichols method, Tyreus and Luyben.

DC motor system is a separately excited DC motor, which is often used to the velocity tuning and the position adjustment. The control equivalent circuit of the DC motor using the armature voltage control method is shown in Fig 2.

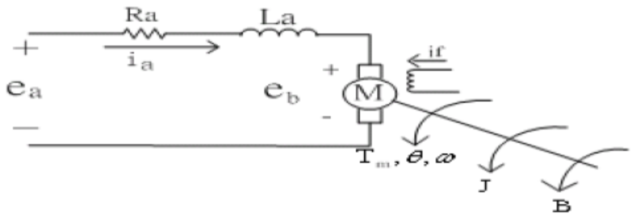

Fig: 2 THE CONTROL EQUIVALENT CIRCUIT OF THE DC MOTOR.

Where

R_a: Armature resistance

L_a: Armature inductance

I_a: Armature current

i_f: Field current

e_a : Input voltage

e_b: Back electromotive force (EMF)

T_m: Motor torque

ω: An angular velocity of rotor

J: rotating inertial measurement of motor bearing

B: a damping coefficient

$$G(s) = \frac{\Omega(s)}{E_a(s)} = \frac{K_T}{(L_a s+R_a)(Js+B)+K_b K_T} \qquad (1)$$

Nowadays, the electromagnetic ovens are used for heating the component assembly of electronic manufacturing. Electromagnetic oven that gives off a constant amount of heat transfers electrical energy by induction from a coil of wire into a metal vessel. The surface temperature of the electromagnetic oven is regulated by varying the amount of cooling it receives. A small electric fan is placed directly in line with the electromagnetic oven so that cool air is forced over it. The amount of heat transfer from the oven is directly proportional to the rate of airflow over it. The system monitors the surface temperature of the element and controls it by varying the speed of the cooling fan as shown in Fig 3.

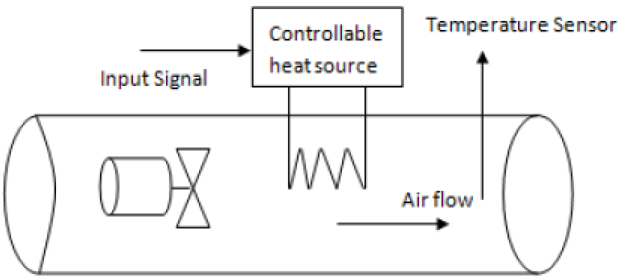

Fig:3 Heat Transfer System

Inside the oven, there is the electrical current controller for electromagnetic lamp and thermocouples are used to perform temperature measurement. The mathematical model of the electromagnetic oven process can be investigated via theory of heat transfer and system identification with linearization. The electromagnetic oven process has the delay time so transfer function from input (the voltage applied to the heating element) to the output (the temperature as seen by the thermocouple) is approximately of the following form.

$$\frac{T_0(s)}{P(s)} = H_0(s) = \frac{K\exp(-sT_d)}{\tau s+1} \qquad (2)$$

Where

$T_0(s)$ - observed or desired temperature,

P(s) - power input (lamp),

K – Gain,

τ - Time constant,

Td - time delay,

K, Td & τ all depend on the speed of the air flow, which changes the transport lag from the heater to the measured output as well as various heat transfer coefficients. It is extremely prevalent in process control applications.

IV. TEMPERATURE CONTROL FOR DYEING

The Dyeing Controller is used in the dyeing process of cloths. The dyeing process is the process of adding colors to the cloths. This project includes mechanism for exact measurement of temperature and the amount of time the cloth is being washed. This would increase the quality of the cloth of the shirt and would be also beneficial for the company making the cloth. In Fig 4, the gradient shows the rate of change of temperature. Temperature shows the value which has to be reached. Hold time shows the time how much temperature has to wait there after reaching it. The range of these parameters is given in table 1. Fig 5 shows the hardware of the project.

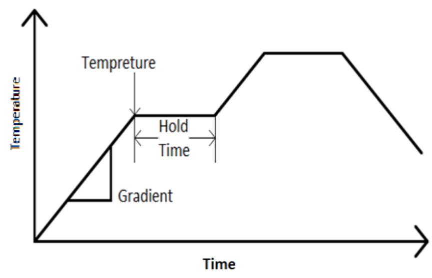

Figure 4: Graph of Temperature versus Time in dyeing Process

Figure 5: Hardware of dyeing controller

INPUT	RANGE	OUTPUT
1.Gradient	0.0 to 9.9	Gradient show the speed of increase of temperature
2.Hold time	0 to 99	Hold time shows the time how much temperature has to wait there after reaching it
3.Temperature	0 to 200	Temperature shows the value which has to be reached

Table 1: Observation Table of dyeing controller

11 Seven Segments are used. Seven Segments are interfaced with PIC16f1939 microcontroller. Seven Segments are controlled by firmware implementation. Seven Segments are used to set various messages by the user. It will display the value of the temperature. The seven segment display used in the project is common cathode. Eight individual LED's are used in each seven segment display. 10 such digits are used to display varies data like temperature, gradient, hold time.

At the basic level, keypad is organized in a matrix of rows and columns. The MPU accesses both rows and columns through the ports. In the project a 4 x 3 matrix is connected to the MPU. The rows are connected to an output port and the columns are connected to an input port. At the input side of the keypad we use 5V.

Platinum resistance thermometers (PRTs) offer excellent accuracy over a wide temperature range (from –200 to +850 °C). The principle of operation is to measure the resistance of a platinum element. The most common type (PT100) has a resistance of 100 ohms at 0 °C and 138.4 ohms at 100 °C. There are also PT1000 sensors that have a resistance of 1000 ohms at 0 °C. For a PT100 sensor, a 1 °C temperature change will cause a 0.384 ohm change in resistance.

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. Relays are used as switches for heat and cool mechanism in the Controller.

V. COMPARISON

THE DESIGN OF TEMPERATURE CONTROL SYSTEM USING PIC18F4620 paper[1] does not include a temperature control mechanism which is present in Dyeing Controller while LabVIEW Based DC Motor and Temperature Control Using PID Controller uses Electromagnetic oven and fan to control temperature paper[2]. Paper[1] and dyeing controller provides a precision of 1 degree while paper[2] does not provide much precision. All three papers have high flexibility. Paper [1] uses LM335 sensor for temperature sensing, while dyeing controller uses PT100 temperature sensor while paper [2] does not use any temperature sensor. Both THE DESIGN OF TEMPERATURE CONTROL SYSTEM USING PIC18F4620 paper[1] and LabVIEW Based DC Motor and Temperature Control Using PID Controller paper[2] does not have any method to control or set Hold Time and Gradient. Dyeing Controller has method to control Hold time and gradient, making it better than the other projects. The comparison is also listed below in table2. From this comparison we conclude that the temperature controller used in dyeing controller is better than the other papers.

Sr. No.	Parameter	THE DESIGN OF TEMPERATURE CONTROL SYSTEM USING PIC18F4620	LabVIEW Based DC Motor and Temperature Control Using PID Controller	Dyeing Controller
1	Controller	PID Controller on PIC16F4620	PID Controller	PIC16F19939
2	Use	Ventilation	DC Motor	Dyeing
3	Temperature Control Mechanism	Not Present	Electromagnetic oven and fan is used to control temperature	Present
4	Temperature Sensor	LM335 sensor	Not used	PT100
5	Precision	1 degree precision	Not precise	1 degree precision
6	Flexibility	High	High	High
7	Hold Time	Is not able to keep the temperature for some specific time	Is not able to keep the temperature for some specific time	Is able to keep the temperature for some specific time
8	Flexibility of Hold Time	Value of hold time cannot be controlled	Value of Hold time cannot be controlled	Value of Hold Time can be controlled
9	Gradient	The rate of change of temperature is not present	The rate of change of temperature is not present	The rate of change of temperature is present
10	Flexibility of Gradient	Value of Gradient cannot be controlled	Value of Gradient cannot be controlled	Value of Gradient can be controlled

Table 2: Comparison of the three system

VI. CONCLUSION

From the above comparison it is clear that THE DESIGN OF TEMPERATURE CONTROL SYSTEM USING

PIC18F4620 does not have a temperature control mechanism which is present in Dyeing Controller. Also in LabVIEW Based DC Motor and Temperature Control Using PID Controller there is no temperature sensor and does not have precision while Dyeing Controller has both present. Both THE DESIGN OF TEMPERATURE CONTROL SYSTEM USING PIC18F4620 and LabVIEW Based DC Motor and Temperature Control Using PID Controller does not have any method to control or set Hold Time and Gradient. Dyeing Controller has method to control Hold time and gradient, making it better than the other projects.

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