Design & Fabrication of a Microcontroller Based Digital Temperature Controller to Control Heater

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Abstract— **Design and fabrication of a heater and a temperature control system to control the temperature of a heater is the main focal of this paper. In thin films deposition temperature is a vital factor. Different thin films deposition method needs different temperature for proper growth of thin films. So a temperature controller is needed to vary the temperature .When measured temperature exceeds the set temperature the microcontroller sends a signal to the Relay resulting in current zero through the heater as a result the heater turns off so a temperature within a certain range(up to 405 ^{O}C) is got. If the set temperature are 50 ^{O}C,150 ^{O}C,250 ^{O}C,350^{O}C,the temperature increased to the set point in 6,16,33,39 minutes respectively.The different components used for controller circuit are available at low cost inns the local market.**

***Index Terms*— Microcontroller, LCD Display, Current Transformer, Thermocouple, Electromagnetic relay, Heater.**

I. Introduction

There are applications where physical properties of material critically depend on temperature. In such cases, accurate temperature measurements and control becomes important to determine, for example, the specific heat of a substance, estimation of semiconductor band gap, determination of the heat transfer rates, thermal expansion coefficients of materials and temperature induced wavelength changes in diode lasers. Then there is another category where temperature control is an essential component in many experimental apparatuses. Examples include, cooled CCD for astronomical imaging and thermally stabilized cavities for high power lasers, crystal growth ovens, cold traps in vacuum line and thermal evaporation and coating chambers. The apparatus temperature in these applications has to be maintained within a few degrees.[1]

Temperature controller can be developed in many ways. Temperature control of a hot plate using microcontroller based PWM technique[2], semiconductor based digital temperature sensors for thermal control applications[1],battery-powered three-mode temperature controller circuit[3].Temperature controller constructed of standard electronic components, uses a thermistor as a sensing element and an ordinary heat lamp or heating strip as a heating element[4]. Among these controllers, none can achieve upper than 100^{O}C.But this microcontroller based temperature can go up to 405^{O}C.

A type of microcomputers that consist of a single silicon chip are called microcontrollers.[5] The system has been integrated with an automatic control arrangement where a microcontroller unit, a character display, a matrix keypad and an electromagnetic relay has been employed. The current and the temperature of the heater are displayed on the LCD.

In thin films deposition temperature is a vital factor. Different thin films deposition method needs different temperature for proper growth of thin films. So a temperature controller is needed to vary the temperature. A matrix keypad was used to put the desired temperature. The current was measured with the help of current transformer and temperature was measured by the thermocouple and both the current and temperature was displayed on the LCD. When the measured temperature exceeds the set temperature the microcontroller sends a signal to the Relay resulting in current zero through the heater as a result the heater turns off so a temperature within a certain range is got.

II. Schematic Arrangement of Proposed Temperature Controller

The block diagram of proposed digital temperature controller is given in Fig. 1.

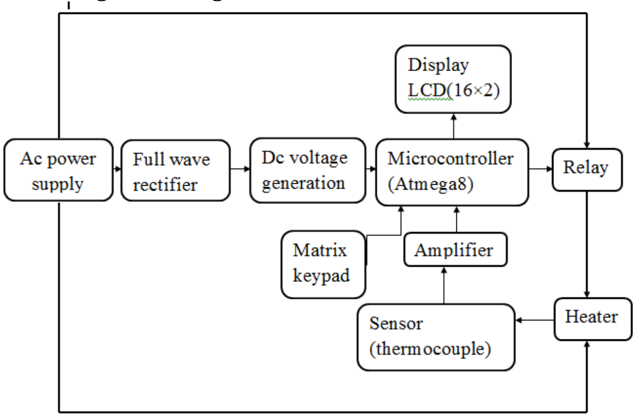

Fig.1. Block diagram of the digital controller

AC supply is essentially required for heater and also required for generation of DC voltage.

Full wave rectifier is needed to convert AC signal to dc signal. It is also necessary for the switching purpose of the transistor that we used.

DC voltage is necessary to generate for the biasing purpose of IC and different electronic devices.

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. An Atmega8 microcontroller is used to send signal (voltage) to the relay to turn on/off the heater.

Liquid crystals do not emit light directly. A QY 162 model 16×2 LCD is used for displaying temperature and current.

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low-power, or where several circuits must be controlled by one signal.

A thermocouple is used as the sensor which converts temperature to an output voltage which is fed to the amplifier circuit for the measurement and displayed on the display through microcontroller.

An electronic amplifier increases the power of a signal taking energy from a power supply and controlling the output to match the input signal shape but with a larger amplitude. An IC TL082 is used for the amplification of the output signal of the thermocouple.

A keypad is a set of buttons arranged in a block or "pad" which usually bear digits, symbols and usually a complete set of alphabetical letters. A 4×4 matrix keypad is used to put the desired input to control the temperature.

Heater consists of high resistive coil. When current passes through it electrical energy is converted into heat energy. A 1400W heater is used here.

III. Complete Circuit Diagram

The figure.2 shows the complete circuit diagram. It may be classified as non-inverting amplifier circuit with negative feedback, Tripping circuit and the microcontroller unit circuit A matrix keypad is used to give the desired set temperature to control to the microcontroller unit. A thermocouple, generating a small voltage proportional to temperature (actually, a voltage proportional to the difference in temperature between the measurement junction and the "reference" junction formed when the alloy thermocouple wires connect with the copper wires leading to the op-amp) drives the op-amp either positive or negative. The TL082 op-amp acts as an amplifier with a large voltage gain. The small voltage generated by thermocouple is amplified by the op-amp

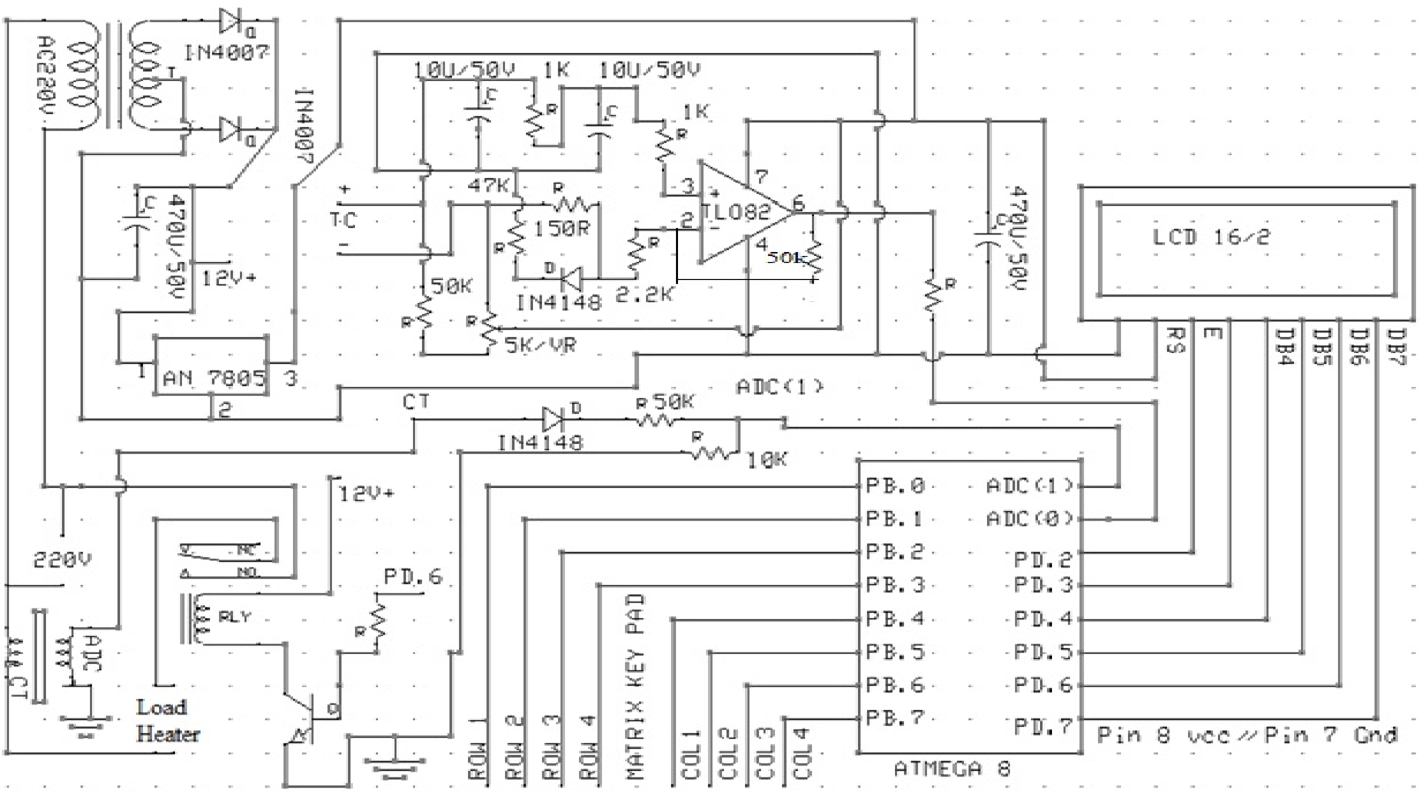

Fig.2. Complete Circuit Diagram

and the output is fed to the ADC port of the Microcontroller. The output signal (voltage proportional to the temperature from microcontroller is fed to the relay coil through a transistor switch. The switching is so adjusted that when the heater temperature is below the set temperature the output of the microcontroller is High and so current flows through the relay coil. So at normal condition that is when the temperature is below the set point the relay is at standby mode i.e. the Heater is connected to a 220V supply and it is turned on. But when the heater temperature is above the set temperature the output of Microcontroller is Low so that no current flows through the relay coil as a result the heater turns off. Again when temperature goes below the set temperature the current flows through the relay and the heater turns on. A diode connected across the relay is used as a freewheeling diode. The temperature and the corresponding current are shown on the LCD.

IV. Complete Arrangement of Temperature Controller

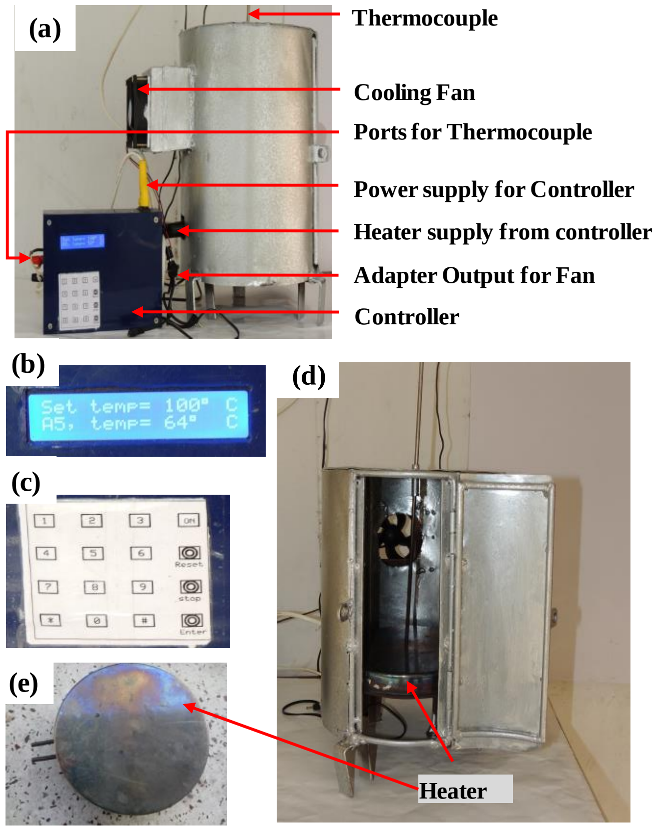

Fig.3.Complete arrangement (a) temperature controller with heater (b)display (c)keypad(d) inner view (e) heater

In these above figures described the fabricated proposed digital temperature to control heater temperature. Fig (a) shows the complete arrangement consist of heater with temperature controller. Fig (b) shows the display unit which shows the temperature Fig (c) shows the keypad to put the desired input to control the temperature. Fig (d) shows the inner view which is surrounded by a metal box. There are door, cooling fan and bush pipe upper it. Fig (e) shows the top view of heater which is 1400W heater.

V. Result

The temperature of the heater was measured for different set temperature with an interval of one minute. The figure shows the variation of temperature with time. As coil is resistive and I^2R power lose increases gradually ,the temperature also increases gradually. When the temperature goes beyond the set temperature the Heater goes to OFF State and after a slight increase the temperature starts to decrease and again when it goes below the set temperature the Heater goes to on state. The process is repeated. Thus temperature within a certain range is obtained. To represent the temperature with time the data obtained for different set temperature is plotted as the temperature vs. time curve with the value of current through the heater.

When the set temperature was 50^OC the temperature increased to the set point by 6 minutes and then the heater turned off and temperature raised to the value of 60^OC and started to decrease. Again when the temperature decreased to the value of 48^OC the heater turned on. This process was repeated. As a result temperature within the range 48^Oc to 54^OC was obtained.

When the set temperature was 150^OC the temperature increased to the set point by 16 minutes and then the heater turned off and temperature rose to the value of 152^OC and started to decrease. Again when the temperature decreased to the value of 148^OC the heater turned on. This process was repeated. So temperature with a range of 148^OC to 152^OC was obtained.

When the set temperature was 250^OC the temperature increased to the set point by 33 minutes and then the heater turned off and temperature rose to the value of 254^OC and started to decrease. Again when the temperature decreased to the value of 248^OC the heater turned on. This process was repeated. So temperature with a range of 248^OC to 254^OC was obtained.

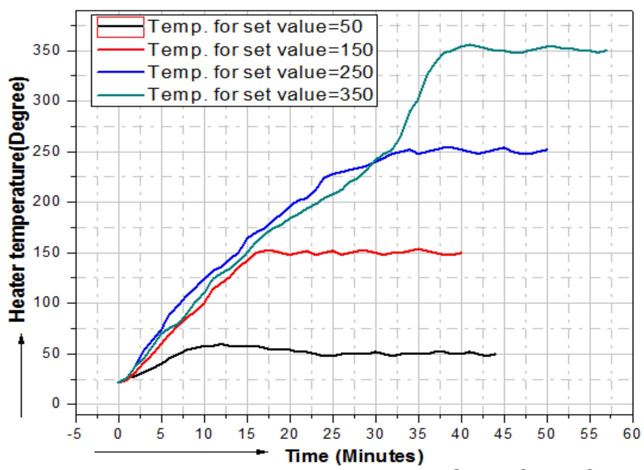

Fig.4. Temperature VS time curve for Set value of 50^OC, 150^OC, 250^OC and 350^OC

When the set temperature was $350^{O}C$ the temperature increased to the set point by 39 minutes and then the heater turned off and temperature rose to the value of $356^{O}C$ and started to decrease. Again when the temperature decreased to the value of $348^{O}C$ the heater turned on. This process was repeated. So temperature with a range of $348^{O}C$ to $356^{O}C$ was obtained. These values are plotted in figure 4.

VI. CONCLUSION

The circuit was constructed on project board & performance was tested in laboratory. By selecting different set temperature we measured the temperature within a time interval of one minute. The temperature was increased in gradually and after obtaining the set value it started to fluctuate in a certain range. We used 1400w heater for this experiment. We got maximum temperature $405^{O}C$ for this heater. There is also a cooling fan attached with the cover of the heater through wood so that heat cannot transfer to the fan resulting no damage of the fan. Modifications can be made. To the controller to accommodate a much wider temperature range, for which a platinum RTD is useful as a temperature sensor. It can be implemented on automobile, cabin, fan, ventilation etc.

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REFERENCES

[1] Ravinder Kumar Banyal and B. Ravindra "Development of a Temperature Controller for the Order- sorting Interference Filters" IIA technical report series, No.10,pp-1-22,2012;Repor no.IIA-TRS-1012

[2] Tabinder Akter, Md. Fazlul Huq , Farzana Alam, Md. Afzalur Rab & Dr.Md.Habibur "Temperature Control of a Hot Plate Using Microcontroller Based PWM Technique" Volume 12 Issue 6 Version 1.0 May 2012

[3] George S. Bakken, "A **B**attery-Powered Three-Mode Temperature-Controller Circuit" j. Therm. Biol. Vol. 8, No. 3. pp. 297-299, 1983

[4] Stephen Yeandle, **"**Electrically Quiet Temperature Controller", Bruin Research Bullerin, Vol. 4, pp. 139-140

[5] K.A Akpado1, C.O Ezeagwu2, A. Ejiofor3, A.O Nwokeke4 "Design, Modeling and Simulation of a Microcontroller Based Temperature Control in a Ventilation System", Vol. 2, Issue 7, July 2013