

Industrial Heating Furnace Temperature Control System

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ABSTRACT

PT 100 temperature sensors are the most common type of platinum resistance thermometer. Often resistance thermometers are generally called Pt100 sensors, even though in reality they may not be the RTD Pt100 type. The temperature of any equipment for every industrial application is controlled by the microcontroller-based temperature control system. At its heart lies the Arm 9 microprocessor, which performs the circuit's entire operations Industrial Heating furnace (IHF). Temperature, is sensed using the PT 100 temperature sensor, which acts linearly with temperature increase. This temperature is compared to the user-saved value, and if it exceeds the preset temperature, the heater turns off; if it falls below the preset value, the heater turns on. An LCD panel displays both the asking and real-time temperatures with human machine interface (HMI). The microcontroller automatically switches on/off a heater or a fan based on the conclusion of the comparison. This proposed paper is separated into two modules, one for temperature monitoring and the other for data collection and also link to personal computer.

Keywords-- Human Machine Interface (HMI), Industrial Heating Furnace (IHF), Temperature

I. INTRODUCTION

Temperature monitoring and control systems are integrated devices that enable users to input specific temperature requirements for any scenario, such as a manufacturing activity. Monitoring and managing process parameters with microcontroller-based embedded systems is very valuable in industrial and research applications in Industrial Heating furnace (IHF)[1]. Temperature is one of the most important parameters to regulate in most production industries such as chemical, food processing, pharmaceutical, material heating like iron, cobalt, and so on. Some products in these industries require the required temperature to be maintained at the greatest priority or the product may fail. As a result, temperature controllers are widely used in practically all sectors [2].

Also, the majority of early temperature controllers and associated systems included discrete component designs such as clocks, counters, decoder drivers, and thermistor temperature sensors. Some, on the other hand, employed microcontrollers with an external analogue to digital converter (ADC) [3]. These gadgets, however, take up a lot of space, are heavier, consume a lot of power, and are less versatile, thus changing the system means replacing physical components. Moreover, among other difficulties, the temperature sensor is non-linear [4].

Almost every industry has a variety of heating and cooling functions, including the textile industry, pharmaceuticals, power plants, and others [5]. For industries to operate efficiently, temperature regulation is a key duty. Each manufacturing sector has certain temperature requirements that must be met during production hours [6]. According to [7], it is essential to carefully monitor and control temperature in industrial settings. The creation of a data logger is the best answer to this issue. Previously, the thermometer and manometer were used to complete it manually. After 1990, people began to develop PC-based data logging systems, which represented another development in data logging. A single programmable system on chip contains a single embedded temperature control design that comprises of a mixed array of analog, digital, and digital communication blocks [8].

The Proposed work has been driven by the fact that temperature measurement has become a fundamental aspect of any control system working in a temperature sensitive environment, as well as the many learning outcomes related with project implementation. An ON-OFF type controller has been implemented in this project. The temperature can be set externally by the user here by use humane Interface system (HMI). The thermocouple temperature sensor measures the actual temperature. The set value is shown on common cathode seven-segment LEDs. If it surpasses the predetermined limit, the heater is shut off. When the temperature goes below the specified level, the heater is turned back on.

The Arm 9 microprocessor and HMI (Human Machine Interface) are utilized in this research to build a temperature control system for the casting process. A

variable resistance with a PT 100 sensor is used to pick the right temperature. The following is how this document is structured: Section II discusses briefly the concept of temperature control technique. Section III includes the PT 100 sensor's function and Arm 9. Section IV Discussion of the observations. Section V presents the proposed paper's conclusion.

II. THE CONCEPT OF TEMPERATURE CONTROL TECHNIQUE

Smooth temperature management is the main function in increasing an industry's output. Different industries have different temperature requirements for specific roles.

Traditionally, an industrial temperature measurement instrument thermometer is used to measure the temperature as shown in figure 1. After examining the temperature reading, the operator adjusts the temperature manually. Controlling is not always ideal due to the time-consuming human operation of cooling and heating devices. As a result, temperature control efficiency fails, and industrial production suffers [9].

Furthermore, thermostats are utilized to select temperature, which is inefficient due to metal corrosion and loss of strength over time. As a result, because it is a mechanically engineered temperature control device, the analog system loses its inherent linearity function. Temperature can be controlled more efficiently via an interface between temperature sensors PT 100, which give a linear voltage signal as the temperature rises, and a microcontroller, which responds in milliseconds. ARM 9 compares the temperature sensor signal to the pre-set temperature value and decides whether to turn on the heating or cooling device and how long the temperature will be maintained in the system. The user can set the temperature externally by using the humane Interface system (HMI). The real temperature is measured by the thermocouple temperature sensor. On common cathode seven-segment LEDs, the configured value is displayed. If it exceeds the predetermined limit, the heater is turned off. When the temperature falls below the set point, the heater is reactivated.

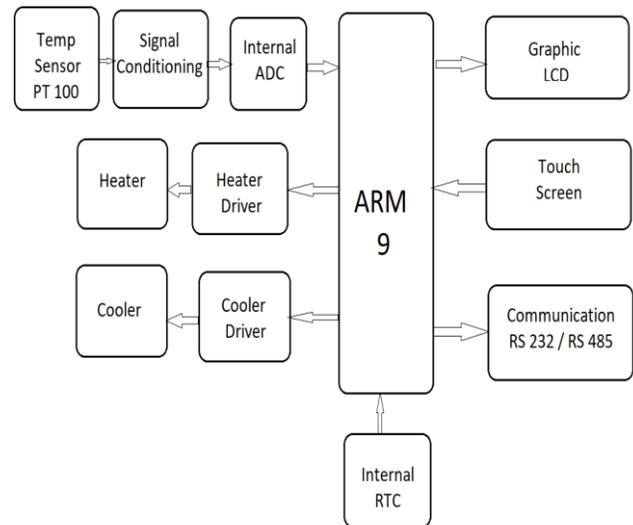


Figure 1: Blockdiagram of system

A. Function of PT 100

A platinum resistance temperature detector (RTD) Pt100 is a device with a typical resistance of $100\ \Omega$ at $0\ ^\circ\text{C}$ (it is called Pt100) and belongs to class of passive (parametric) sensors [1]. It changes its own resistance value as the temperature changes following a positive slope (resistance is increasing with temperature increasing) [2]. To measure those resistance variations, the external supply is needed. In general, the transducer working characteristic (transfer function) is the relation between measured physical value and appropriate electrical output. A platinum resistance temperature detector (RTD) Pt100 is a device with a typical resistance of $100\ \Omega$ at $0\ ^\circ\text{C}$ (it is called Pt100) and belongs to class of passive (parametric) sensors [1]. It changes its own resistance value as the temperature changes following a positive slope (resistance is increasing with temperature increasing) [2]. To measure those resistance variations, the external supply is needed. In general, the transducer working characteristic (transfer function) is the relation between measured physical value and appropriate electrical output.

The Pt100 device, also known as a platinum resistance temperature detector (RTD), is a passive (parametric) sensor with a typical resistance of $100\ \Omega$ at $0\ ^\circ\text{C}$ [10]. It alters its own resistance value when the temperature changes, having a positive slope (resistance increases as temperature increases) [11]. The external supply is required to measure the resistance fluctuations. In general, the transducer working characteristic (transfer function) is the relationship between observed physical value and acceptable electrical output as shown in figure 2.

Applying a certain current value results in output voltage rising with temperature since RTD resistance is related to temperature. Knowing the precise link between resistance and temperature enables us to determine the

measured temperature value. The Pt100 relationship (measurement characteristic) looks to be relatively linear in practice; however the working curve is not a perfect straight line, as shown in Figure. 2. The generic equation that shows the nonlinear relationship between temperature and resistance could be used to describe it.

The Pt100 sensor, like many others, has a nonlinear transfer function. Even though PRTDs are the most linear detectors, they nevertheless have many degrees of inaccuracy across the whole measuring range. This level of accuracy is unacceptable for some applications.

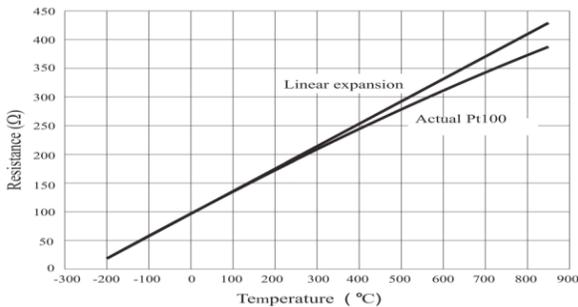


Figure 2: Pt100 transfer function.

B. Function of ARM 9

The ARM term indicates for Advance Risk Machine, and it refers to one of the most widely used and licensed CPU cores in the world. Thus, ARM controllers are particularly popular in portable devices such as mobile phones, digital cameras, wireless communication technologies, home networking modules, and other ARM-based projects due to benefits such as appropriate performance and low power consumption.

Applications like this exemplify Moore's law, prompting ARM to create the ARM9 series of microprocessors [12]. These devices are based on the ARM7 architecture and offer increased performance. ARM9 processors are specifically designed to fulfill the needs of the next generation of highly integrated portable applications while minimizing power consumption and die size.

To measure and regulate the temperature, an ARM-based monitor and control system is used. The system has been tested, and the results show that it is faster than a typical system that does not use ARM or HMI. The use of this device requires less electricity and less processing time. The traditional system demands more computing power and time. For this system, the temperature measurement error is less than 0.5%.

The ARM9 is a powerful ARM controller/processor. It has a high efficiency, dual-issue sub scalar, and a pipeline with a dynamic length (8-11 stages). It has both a light burden and high performance. The performance of ARM9 is superior to that of ARM7. It

is currently utilized in cellphones and digital television, as well as consumer gadgets.

C. PID Controller

The PID controller is a popular feedback network tool due to its clarity, ease of implementation, and ability to reduce the difference between process variables and set points. It offers zero steady state error, fast response, short rise time, no oscillations, and higher stability. PID controllers are preferred over PI controllers due to their reduced overshoot and employability for higher order systems.

It is widely utilized in the chemical industry due to its high rate of success in practical applications, robustness, and simplicity. The PID temperature control method is used for practically all loop control in the process industries and serves as the foundation for many advanced control algorithms and strategies. A PID temperature controller generates an error signal by monitoring the current temperature and adjusting the output to get it closer to the target temperature. The major alternative for temperature PID controller is an ON/OFF controller, which functions similarly to a thermostat. The best controller for a temperature-controlled process is found using the results of time domain and error criterion analysis. The best tuned controlled technique is identified as a good outcome of lowest rising time, setting time, and overshoot [7].

III. RASPBERRY Pi

The Human Machine Interface (HMI) allows for simple control, and a PID temperature controller is a popular option. It measures current temperature, generates an error signal, and adjusts output to achieve a target. The ON/OFF controller, like a thermostat, is the most suitable for temperature-controlled processes.

IV. DISCUSSION OF OBSERVATIONS

The C language is used to compile the microcontroller code on ARM 9. Temperature measurements with the help of PT 100 have been used in regular tests for the hardware validation. This PT 100 sensor transmits voltage for the associated temperature to the microcontroller, which then compares it to the requested temperature. The heater is turned on and the cooling fan is deactivated when the requested temperature is higher than the actual temperature. Similar to this, when the requested temperature is lower than the actual temperature, the heater is shut off while the cooling fan is running. The time domain response can be simply adjusted by the operator using the HMI, and this data is sent to the PC for further use.

The microcontroller sends the output voltage to the base of a common emitter configuration transistor, which then starts the current flow by switching on the heater or cooling fan, to turn on and off the heater and cooling fan, respectively.

V. CONCLUSION

As temperature-controlled operations, the Human Machine Interface (HMI) enables for simple control, and a PID temperature controller is used. The time domain response using HMI offers the operator easy control, and this data is sent to the PC for further usage. It takes the current temperature, generates an error signal, and changes the output to meet the goal. The ON/OFF controller, which functions similarly to a thermostat, is ideal for temperature-controlled processes. PID controllers offer automatic tuning, which attracts the attention of industrial users. PID controller tuning is a broad study field with nearing experimental and theoretical results. HMI designs can be tailored to a variety of channels and users.

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