ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 2, February 2014

Data Acquisition System of 8-Channel Temperature Scanner using Power Line Carrier Communication

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Abstract: An embedded temperature control system based on eight channel temperature scanner has been designed to monitor and control the temperature in brazing furnace which is mainly used for the production of radiators in automotive industry. The temperature monitoring and controlling in furnace brazing based on Power Line Carrier Communication (PLCC) has been introduced, which contains technical composition and characteristics even the realization process. This paper initiates the accomplishment of sensor nodes and describes the construction and design of monitoring system. The sensor has to be connected to the microcontroller and varying temperature has been sent to Power Line Modem (PLM). The power line technology provides users with high quality digital communication. The system can monitor and control the different temperature parameter of a furnace brazing in real-time, and analyze the data with the use of data acquisition system(DAQ).In the PC(Personnel Computer) based DAQ various temperature parameters has been monitored and controlled through PC based data acquisition system.

Keywords: DAQ, PLCC, PLM, PC

I. INTRODUCTION

Temperature is a very critical and widely measured variable for engineers. Many processes must have either a monitored or controlled temperature. Temperature monitoring and controlling of furnace as furnace brazing application which are used in automotive industry is very crucial for increasing lifetime of the machine. A continuous real time monitoring and controlling system has been developed with the use of data acquisition system. A real time PC based logging systems can be used for the measurement, monitoring and controlling of different temperature parameters of furnace. Data storage and recording is a very common measurement application. In its most basic form, data storage is the measurement and recording of different temperature parameters over a period of time.

Brazed aluminum heat exchangers are largely utilized in modern automobiles for all major engine cooling and climate control systems such as condensers, evaporators, radiators, oil coolers and charge air coolers. In addition, various heat exchangers are braced for home appliances and industrial applications. Gas shielded continuous brazing furnace as a device for metal brazing and continuous thermal treatment and it is mainly used for the production of filter refrigeration part of automotive industry. In the brazing process, work piece through a brazing furnace, in a certain atmosphere, is heated to the necessary temperature to complete the brazing process. Partition heating mode is used during the brazing process, there are four heating temperature zones and a temperature of each heating zone must be controlled accurately, to maintain the uniformity of the heating zone. Several papers which were discussed about the temperature measurement and control using different types of sensors and controllers. A Data Acquisition system (DAS) which was based on Remote Terminal Unit (RTU) has been discussed. In this work, power line communication (PLC) system was used in distribution system functions in an automated manner [1]. In blast furnace, controlling methods of both soft water measurement and heat load have been discussed. In this work, DS18B20 digital thermometer was used as a temperature sensor [2]. The process of temperature control system has been developed based on network communications through VB, and this work were demonstrate the programming of the real-time control and temperature monitoring system through Programmable Logic Controller (PLC)[3]. A data acquisition system with the use of optical fiber connection for data transmission has been discussed. The improved data acquisition platform was realized with the use of PIC 16F877 microcontroller and it uses optical transmitters and receivers for electro-optical conversion of the signals [4]. A developed a mathematical model for industrial brazing furnace were discussed. Two popular intelligent control algorithms that are fuzzy control and human-simulated intelligent control were presented [5].

This project focus is to develop a data acquisition system for monitoring various temperature parameters in different zones of the brazing furnace .The data has to be monitored are taken from the field and collected data has been transmitted to the centralized control room using power

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Line carrier communication. The system uses power line communication for this purpose. A data acquisition system has been designed and developed using microcontroller with RTD (Resistive Thermocouple Detector) PT1000 temperature sensor. Power Line Modem(PLM) is used to send the sensed temperature to microcontroller. In the control room, the data received by power line communication, will be decoded by the microcontroller system and will be displayed in data acquisition mimic.

The objective of this paper is to design and develop a wired communication link to monitor and control equipment's that are far away from the user and also develop a high security system for monitoring and controlling different temperature parameters in furnace brazing. The goal of the project is to design an 8 channel Data Acquisition System (DAQ) for monitoring and controlling different temperatures in four different zones and the data transmission takes place over the power line cables. Finally, different temperature has to be monitored and controlled in PC based data acquisition system. The goal of a brazing furnace is to provide a time, temperature relationship that is accurate, continuous and economical in meeting the requirements of the brazing process.

II. SYSTEM DESCRIPTION

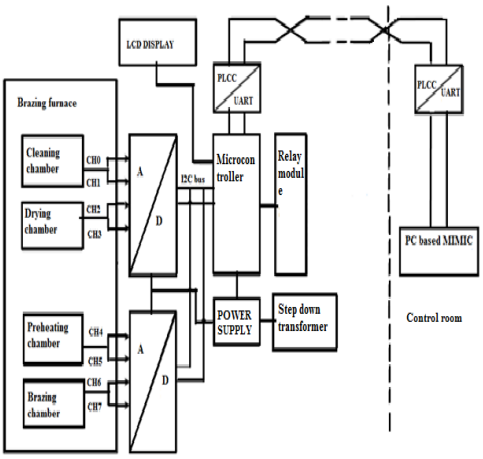

Fig.1. Block diagram

CH0 –Cleaning chamber inlet temperature
CH1-Cleaning chamber outlet temperature
CH2-Drying chamber inlet temperature
CH3-Drying chamber outlet temperature
CH4-Preheating chamber inlet temperature
CH5-Preheating chamber outlet temperature
CH6-Brazing chamber inlet temperature
CH7-Brazing chamber outlet temperature

For furnace brazing, four main chambers that is cleaning chamber, drying chamber, preheating chamber, brazing chamber inlet and outlet temperature has to be monitored using 8 channel temperature scanner in the form of analog data which is shown in Fig.1. The analog data has been converted into digitized signal using Analog to Digital Converter (ADC). Liquid Crystal Display (LCD) is used to display the signal in the form of digital. The received temperature signal of furnace for four different zones is then send to the microcontroller. Both transmission and reception stages of furnace temperature monitoring are controlled by the microcontroller. The main role of microcontroller is to check received temperature signal for furnace with the prepared program available inside the microcontroller. Depending on this several relay has to be operated.

III. PHYSICAL MODEL OF THERMAL PROCESS

The thermal efficiency of a furnace is usually expressed by the ratio of heat transfer to the energy input in the fuel. There are three basic mechanisms used for heat transfer are thermal radiation, conduction and convection. Heat transfer equation for furnace brazing is given by;

$$Q = m \times c \times \Delta T \quad (1)$$

Where m is the mass, C is the specific heat and ΔT is the temperature difference in K.

Heat transfer conduction formula for brazing furnace is given by;

$$Q = \frac{kA\,(TH-TC)t}{d} \quad (2)$$

Where k is the thermal conductivity of the material, A is the cross sectional area, TH is the higher temperature TL is the cooler temperature, t is the time taken, d is the thickness of the material.

Furnace heat transfer convection formula is given by;

$$Q = H_C A\,(TH\text{-}TC) \quad (3)$$

Where H_C is the heat transfer coefficient, the heat transfer by radiation is given by;

$$Q = T^4\,H\text{-}T^4\,C \quad (4)$$

Where $T^4\,H\text{-}T^4\,C$ is the difference between higher and lower temperature.

IV. GENERAL DESCRIPTION OF THE HARDWARE AND SOFTWARE

Furnace brazing temperature monitoring and controlling system incorporates RTD (Resistive Thermocouple detector) temperature sensor,8 channel thermocouple data logger(TC-08), Microcontroller unit(TMS 470 16/32bit RISC microcontroller), Power Line Modem-TDA5051A . The description of hardware and software has been described in below.

A.HARDWARE DESCRIPTION

The basic requirement of hardware components has been described in below.

A.1.RTD (Resistive Thermocouple Detector) temperature sensor

RTD temperature sensor is specifically used for sensing temperature parameters in different zones for furnace brazing system. Resistance thermometers offer greater stability, accuracy and flexibility in some cases repeatability than thermocouples. The Pt100 sensor is most common type of RTD sensor has a resistance of 100 ohms. While compared to the Pt100 the resistance of the Pt1000 at 0 °C is not only 100Ω but 1000 Ω. The advantage resides in the higher sensitivity respectively resolution, which means a stronger change of the resistance during temperature change. The Pt 1000 sensor is usually made to have a resistance of 1000 Ω at 0°C.

A.2.Microcontroller unit (TMS 470 16/32bit RISC microcontroller

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TMS470 is a 16/ 32-bit reduced instruction set computer (RISC) Microcontrollers is specifically used for processing and controlling different temperature parameters of furnace brazing. The TMS470PLF111 Microcontroller provide high performance 16/32-bit RISC central processing unit (CPU), resulting in a high instruction for greater code efficiency. The PLF111 device has provide one 10-bit-resolution.It provide data transmission through serial communication protocol I2C (Inter-Integrated Circuit) serial bus which supports both 100 Kbps and 400 Kbps speeds. The main functionality of the microcontroller is to acquire the temperature through the RTD temperature sensor.

A.3.Power Line Modem (TDA 5051A)

TDA5051A is mainly used for transmitting and receiving different temperature of brazing furnace by means of ASK (Amplitude Shift Keying) transmission. It can be used to transmit and receive data at 600 baud or 1200 baud data rate. TDA5051A operates at single 5V supply and provide easy connection to microcontrollers. It employs 8-bit analog-to-digital converter and both modulation/demodulation set by the clock of microcontroller. The furnace temperature of both transmission/reception through TDA5051A power line modem which is shown in Fig.2.

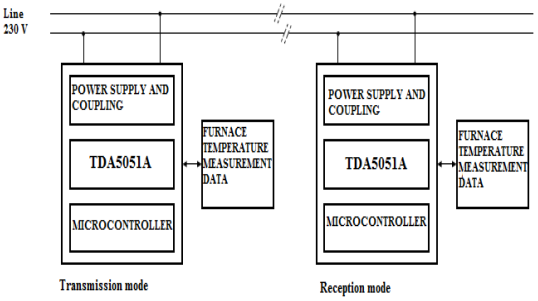

Fig.2.Furnace temperature transmission/reception through TDA5051A

The modem at the transmission end recovers the temperature data through the use of power line modem. The receiving end the modem demodulates the temperature signal through the use of power line modem.

B. SOFTWARE DESCRIPTION

The program is written in Embedded C in Keil µVision3. Integrated Development Environment (IDE) is an integrated toolset for the development of embedded application employing microcontroller. The compiler tool is used to convert C Language to HEX File. The HEX file is dumped into the microcontroller using proteus electronic tool.

V. PROTOTYPE DESIGN SOFTWARE SIMULATION LAYOUT

In this present work software has been developed with the use of proteus software. µVision3 is an IDE (Integrated Development Environment) that helps to write, compile, and debug embedded programs in proteus tool. The 8channel ADC interfacing with microcontroller has to be shown in below Fig.3.

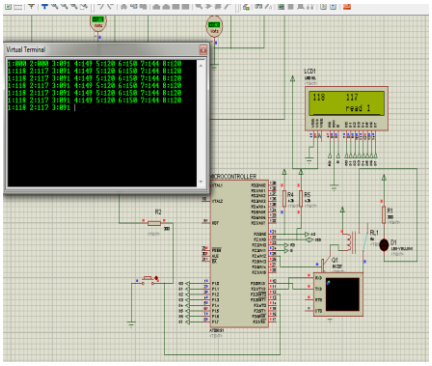

Fig.3.Interfacing 8-channel ADC with microcontroller

The above circuit provides 8-channel ADC interfacing with microcontroller using LM35 temperature sensor. In this circuit, 8bit I2C bus of two PCF 8591 ADC is attached with the microcontroller. LCD is attached on port 1 of the microcontroller. Relay should be attached with the port 2.4 of the microcontroller. The address and clock lines i.e. SCL and SDA will be attached to the port 2.0 and port 2.1 of the microcontroller. P 2.2 pin is used as Reset (RS) and P 2.3 pin is used as Enable (EN). In first ADC, PCF 8591 has 4 channels i.e. IN0, IN1, IN2, IN3. In this, four LM 35 temperature sensors are attached with IN0, IN1, IN2, and IN3. A potentiometer (i.e. variable 10K resistance) is attached with the voltmeter for setting reference voltage as 1.5V. Again the volt meter has been attached with the LM 35 temperature sensor. The voltage can be varied according to the temperature changes. In second ADC, also the working principle has to be same as the first ADC. Virtual Terminal that is both TXD (Transmit/data) and RXD (Receive/data) has been attached with port 3.0 and port 3.1 of the microcontroller for the purpose of serial communication. Finally the temperature reading has to be displayed one by one in LCD. In virtual terminal, the temperature has to be sensed from 8 temperature sensor then readings have been displayed serially.

VI. EXPERIMENTAL SETUP

The temperature of different furnace zones has been monitored and the temperature has to be measured more accurately with the use of data acquisition system (PC/Laptop). The temperature monitoring of such furnace chambers which is shown in below Fig.4.

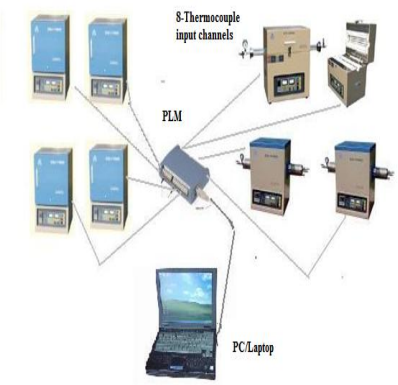

Fig.4.Experimental setup for furnace chamber temperature monitoring

The four main chamber temperature that is cleaning chamber, drying chamber, preheating chamber, brazing chamber temperature monitored continuously through the power line modem and it has been measured and controlled more accurately.

VII. CONCLUSION

The device temperature parameter of different zones of furnace has been constantly monitored and hence it can be further controlled by using data acquisition and control system. The constant monitoring of such different furnace zone temperature can produce data-base for scheduling of the machine servicing, troubleshooting and also for future references. Due to use of microcontroller the computation task has been handled most effectively. Hence the proposed system has been widely used in automotive engineering, instrumentation and power quality monitoring and control applications. Data acquisition system for monitoring such temperature of brazing furnace provides advantages of design simplicity, portability and less cost.

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