Thermocouple Based Fire Warning System for Piston Engine

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Abstract **- The aim of the project is to develop a thermocouple based fire warning system for piston engine as the system detect the engine overheat or fire warning alert is given to the through pilot headphone using speech synthesis and audible. The aspects of fire protection is to identify a developing fire emergency in timely manner and alert the pilot to take the sufficient precautionary action. In this paper attempt has been made to detect the fire which originate from the engine sense by a thermocouple sensor. This sense signal are feedback to the engine fire warning system which an alert the signal to the pilot.as the system detect the engine fire warning through the pilot headphone using by speech synthesis and audible.**

Keywords: Thermocouple; piston engine; PCB board; ZigBee; headphone or speaker;

1 INTRODUCTION

This paper thermocouple based fire warning system for piston engine will focus on the system that will detect and control fire accidents in the piston engine aircraft. The main objective of our proposed system is to aircraft safety, safe guard people life, and pilot lives. Fire in the air one of the most hazardous situation that a flight engine might be faced with. If increase Piston engine temperature than predetermined limit the detector sense overheat condition. The thermocouple sense both fire and overheat detection. As the temperature of a detector increase to a detector predetermined limit, the detector sense an overheat detection, at higher temperature the sense a fire condition. Aircraft piston engine temperature is approximately 650 degree Celsius to 1200 degree Celsius. A combined total of 8thermocouple sensor used to detect temperature and high temperature measurement were installed at critical location in engine compartment of prototype com air CA12. Piston engine temperature measurement using by thermocouple K type sensor measurement range of sensor -200^{o}c to +1250^{o}c. thermocouple over the last few years sensors have seen an increased acceptance as well as a widespread for temperature and high temperature sensing in an airborne deportment and industrial applications. The thermocouple operation simple and instrumentation have become well understood and developed variety of commercial sensor readily available. The fabricate transmitter unit and receiver unit using PCB board design that can record digital or analog measurement over a period of time. It is consists of the power supply unit, analog to digital converter, 8051 microcontroller, sensor, ZigBee, LCD and audible driver circuit. The thermocouple detect engine overheat this signal send to ADC it is converts the analog signal to digital format LCD shown the temperature level. ZigBee transmit the all data to receiver if increase the engine temperature predetermined limit driver circuit convert speech synthesis and fire warning through pilot headphone using audible speech synthesis. After receiving alert signal pilot will landing the aircraft and take necessary action.

II METHODOLOGY

1A. thermocouple

Thermocouples are by far the most widely types of sensor in industry. They are very rugged and can be used from subzero temperature to temperature well over2000^{o}C. The thermocouple is simple widely used component for measuring temperatures. There are many types of thermocouple from which to choose. K type of thermocouple is most popular because the lower price, those made of low cost metals and temperature measurement range high so have selected this type of sensor. A Thermocouple is a temperature measuring device consisting of two conductors of dissimilar metals or alloys that are connected only at the ends the thermocouple measures temperatures between -200 and 1250 °Type K thermocouple wire is used. ChromelÔ1 (chromium - nickel) wire and Almelo (aluminium - nickel) wire are twisted together to form two junctions. The thermal voltage is proportional to the temperature-difference between the junctions. One of the junctions, the reference junction on the end of the black socket, is placed where its temperature is kept steady. The thermocouple measures temperatures between -200 and 1250°C. When the ends are at deferent temperatures, a small voltage is produced in the wire that can be related directly to the temperature deference between the ends. If the temperature at one end is known, the temperature at the other end can be determined. Thermocouple wire or extension grade wire is used to connect the thermocouple to the sensing or control instrumentation. The conditions of measurement determine the type of thermocouple wire and insulation to be used. Temperature range, environment, insulation requirements, response, and service life should be considered when selecting a wire type. These thermocouples are inexpensive, accurate and used in the majority of industrial applications. Thermocouple selection depends upon cost, temperature range, accuracy of temperature measurement. Most likely we will use type J or type K thermocouple sensor.

Figure1. Thermocouple sensor image

B. Thermocouple Sensor Specifications

Temperature range	: 0 to 1250 degree Celsius
Accuracy	: +0.5
Conductors	: chrome (+), alumel (-)
Responsiveness	: less than 1
Excitation	: none required
Form of output	: voltage
Premium grade	:"kk"

C. Thermocouple Principles

Thermocouples rely on the voltage produced by a temperature difference between two junctions formed between thermoelectrically dissimilar metals In other words, a thermocouple is simply two different types of metals, usually in the form of wires, connected together. The voltage is produced because a temperature gradient in a metal conductor also induces a gradient in electron density in line with the temperature gradient. When the measuring junction is heated a small dc voltage generated in thermocouple wires. The controller this millivolt signal and converts into a temperature reading. The voltage generated in the thermocouple is so small that is measured in millivolts. The thermal energy is somehow inducing thermocouple converts thermal energy into electrical energy. The temperature controllers uses this electric energy to measure thermocouple temperature.

2 A.Piston Engine

Aircraft reciprocating (piston) engines are typically designed to run on aviation gasoline(petrol), which has a higher octane rating as compared to automotive gasoline(petrol), allowing the use of higher compression ratios, increasing power output and efficiency at higher altitudes. The most common fuel for aircraft engines has an octane rating of 100 octane and low lead content. Aviation fuel is blended with tetra-ethyl lead (TEL) to achieve these high octane ratings, a practice no longer permitted with road vehicles for pollution. The piston is returned to the cylinder top (Top Dead Centre) either by a flywheel or the power from other pistons connected to the same shaft. In most types the "exhausted" gases are removed from the cylinder by this stroke. This completes the four strokes of a 4-stroke engine also representing 4 legs of a cycle. The linear motion of the piston is converted to a rotational motion via a connecting rod and a crankshaft. A flywheels used to ensure continued smooth rotation (i.e. when there is no power stroke). Multiple cylinder power strokes act as a flywheel. The more cylinders a reciprocating engine has, generally, the more vibration-free (smoothly) it can operate.

B. Engine Specifications

Engine combustion chamber gas temperature approximately650^{o}C to 1200^{o}C degree Celsius

Temperature of piston heat is 200 degree Celsius

Pressure of maximum power stroke engine up to 3to 5mpa diesel engines up to 6 to 9 mpa

High speed (8 to 12m/s) reciprocating motion and the speed is constantly changing.
Helps reduce oil consumption by up to 50% and provides superior oil flow at low temperatures.

- Engine Briggs & Stratton model 110602 type 0015
- Bore 68.275 mm
- Stroke 45.720 mm
- Displacement 167.38 cm3
- Connecting rod length 88.6 mm
- Wrist pin offset 0.381 mm
- Combustion chamber Pancake Style
- Geometric compression ratio 6.6:1
- Valve configuration Overhead, single intake, single exhaust
- Rated speed 3060 rpm
- Power rating 4.8 kW

Figure2. Aircraft piston engine

III HARDWARE IMPLEMENTATION

It involves the details of the set of design specifications. The hardware design consists of, the selection of system components as per the requirement, the details of sub-systems that are required for the complete implementation of the system and full hardware schematics for the PCB layout. Design of the circuit and its testing has been carried out. It involves the component selection, component description and hardware details of the system designed.

A. Hardware Design Block Diagram

Thermocouple based fire warning system consists of transmitter and receiving section include. The hardware design consists of, the selection of system components as per the requirement, the details of sub-systems that are required for the complete implementation of the system and full hardware schematics for the PCB layout.

TRANSMITTER UNIT:

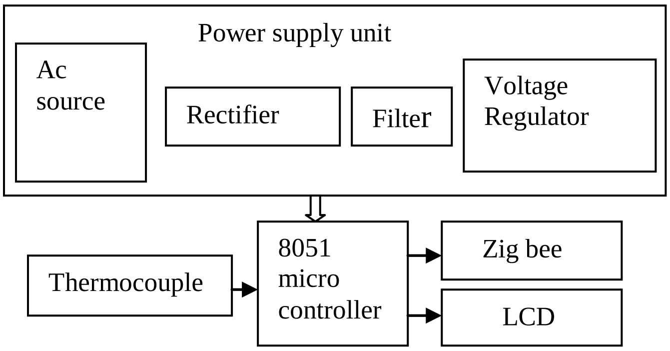

Figure3.Transmitter Unit Block Diagram

RECEIVER UNIT

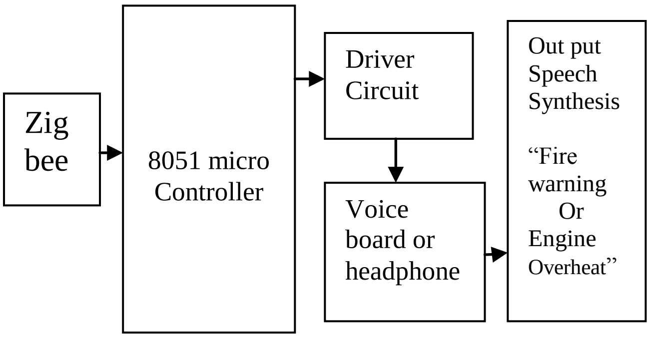

Figure4. Receiver Unit Block Diagram

B. Component Selection and Description

Temperature measurement using microcontroller based thermocouple includes the following components:

- Power Supply
- Thermocouple sensor
- Analog to Digital Converter (ADC 0808)
- 8051 Microcontroller
- Liquid Crystal Display (LCD)
- Zig bee
- Driver circuit

1. Thermocouple

A thermocouple is a temperature measuring device consisting of two conductors of dissimilar metals or alloys that are connected only at the ends. When the ends are at different temperatures, a small voltage is produced in the wire that can be related directly to the temperature difference between the ends. If the temperature at one end is known, the temperature at the other end can be determined. Thermocouples rely on the voltage produced by a temperature difference between two junctions formed between thermoelectrically dissimilar metals In other words, a thermocouple is simply two different types of metals, usually in the form of wires, connected together. The voltage is produced because a temperature gradient in a metal conductor also induces a gradient in electron density in line with the temperature gradient. When the measuring junction is heated a small dc voltage generated in thermocouple wires. The controller this millivolt signal and converts into a temperature reading.

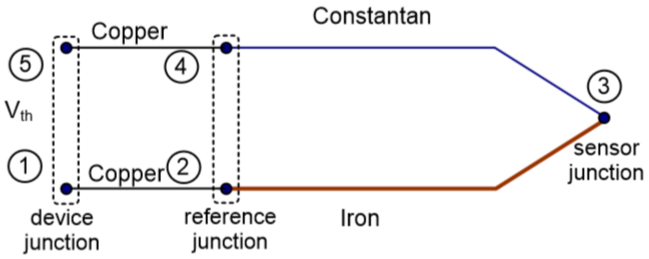

Figure5.thermocouple temperature measuring circuit

2. Analog to digital converter (ADC)

In physical world parameters such as temperature, pressure, humidity, and velocity are analog signals. A physical quantity is converted into electrical signals. We need an analog to digital converter to translate the analog signals to digital numbers so that the microcontroller can read them. Thus, an analog-to-digital converter (ADC) is an electronic circuit that converts continuous signals to discrete digital numbers. Analog to digital converters are the most widely used devices for data acquisition.

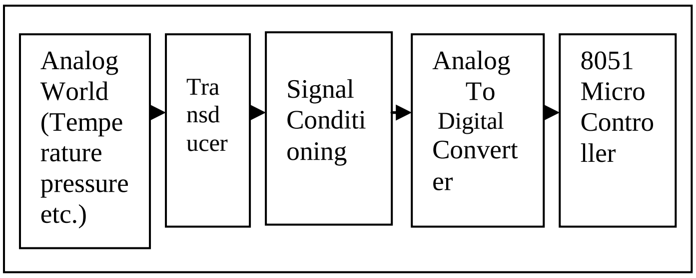

Figure6. Getting data from analog world

The ADC 0804 is most widely used chip. For this work, the analog to digital converter chosen is ADC 0809. Because ADC 0804 has only one analog input, this chip has 8 of the analog inputs.

3. Microcontroller chip

The 8051 family of microcontrollers is based on an architecture which is highly optimized for embedded control systems. It is used in a wide variety of applications from Military equipment to automobiles to the keyboard. Second only to the Motorola 68HC11 in eight bit processors sales, the8051 family of microcontrollers is available in a wide Array of variations from manufacturers such as Intel, Philips, and Siemens. These manufacturers have added numerous features and peripherals to the 8051 such as I2C interfaces, analog to digital converters, watchdog timers, and pulse width modulated outputs. Variations of the 8051 with clock speeds up to 40MHz and voltage requirements down to 1.5 volts are available. The 8051 microcontroller is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). By combining a versatile 8-bit CPU with Flash on a monolithic chip, the 8051microcontroller is a powerful microcomputer, which provides a highly-flexible and cost-effective solution to many embedded control applications.

The basic architecture of AT89C51 consists of the following features.

- An eight bit ALU
- 32 discrete I/O pins (4 groups of 8) which can be individually accessed
- Two 16 bit timer/counters
- 6 interrupt sources with 2 priority levels
- 128 bytes of on board RAM
- Separate 64K byte address spaces for DATA and CODE memory

One 8051 processor cycle consists of twelve oscillator periods. Each of the twelve oscillator periods is used for a special function by the 8051 core. Therefore, if you have a system which is using an 11.059MHz clock, you can compute the number of instructions per second by dividing this value by 12. This gives an instruction frequency of 921583 instructions per second. Inverting this will provide the amount of time taken by each instruction cycle (1.085 microseconds).

3. Liquid Crystal Display

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It uses very small amounts of electric power, and is therefore suitable for use in battery-powered electronic devices. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other. More microcontroller devices are using 'smart LCD' displays to output visual information.

4. Zig Bee

ZigBee is a considered as a path for a suite of high level communication protocols. ZigBee is generally called as wireless communication technology. ZigBee also support low rate and low-power digital radios based on an IEEE 802 standard for personal area networks PAN. The purpose of the technology defined by the ZigBee specification is to be simpler and less expensive than other WPANs (Wireless personal area network), such as Bluetooth. ZigBee is aimed for radio-frequency RF applications because they require a less data rate, high battery life, and for secure network. ZigBee has a defined rate of 250 kbps best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. The ZigBee Alliance is not pushing a technology; rather it is providing standardized base set of solutions for sensor and control systems.

IV SOFTWARE DESIGN AND DEVELOPMENT

Software design includes developing algorithm for the system, allocating memory blocks asper functionality, writing the separate routines for different interfacing devices and testing them on the designed hardware. Interfacing of microcontroller with ADC, LCD, etc. has been carried out using various software modules. The control program is written in assembly language. The software is able to show the real time values from the analog channels for immediate analysis. For designing the software for this work; the flow of software between the hardware components is to be understood first.

1. Interfacing ADC0808 with the microcontroller Algorithm for interfacing ADC 0808 with microcontroller is as:

1. Firstly, the address lines ‘adc_adr0’ and ‘adc_adr1’ are selected.
2. The start of conversion line ‘adc_start’ is set and then cleared.
3. The end of conversion line ‘adc_eoc’ is then checked. If it satisfies the condition ‘adc_eoc’=0, the output enable line ‘adc_oe’ is set; otherwise it will execute the loop until the condition is satisfied.
4. In the next step, the contents of port 0 are moved to the acquired channel.
5. Finally the output enable line ‘adc_oe’ is cleared. And the loop is executed till all the channels are selected.

2. Interfacing LCD to the microcontroller

For interfacing a LCD to the microcontroller it has to be first initialized then command and data are sent to it.
Algorithm for initializing the LCD is as:

1. Firstly, the interface length is set.
2. A high to low pulse is applied to the pin ‘en_lcd’.
3. A delay of 20 Ms is then called.
4. The display is turned on and a high to low pulse is again applied to the pin‘en_lcd’.
5. The cursor move direction is set in next step and shift of display is specified.
6. A delay subroutine of 50 Ms is called and a high to low pulse is applied to pin‘en_lcd’.

V. RESULTS AND ANALYSIS

1. Aircraft piston engine temperature measurement

In this system, Temperature measurements from piston engine using 8thermocouple sensor.have checked piston engine during running condition checked temperature variation graph. Knowing the sensor location is important for future use since the temperature profile can vary greatly over the piston crown area. A piston that had completes the sensor embedding process was sectioned to examine how well the sensor placement differed from the desired location. The piston was cut into four pieces giving a total of eight end views. This method was successful for measuring temperature within a stationary engine.

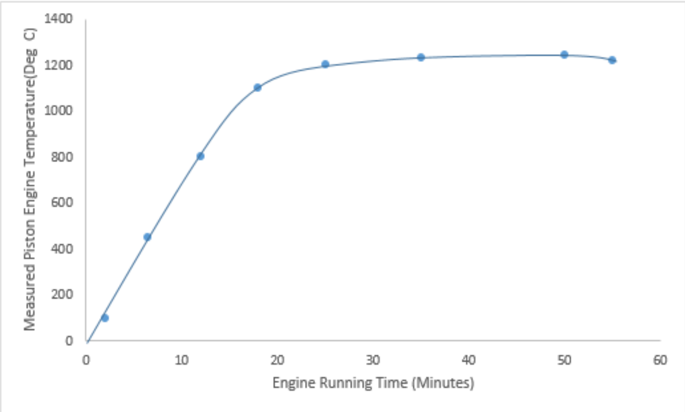

Figure7. Piston temperature variation with running time as measured in a stopped engine

To accomplish this measurement a scan was taken at with the engine at rest at room temperature. The engine was then run for three minutes, stopped, the optical path aligned and a Temperature measurement taken as soon as possible. At least two more repeats cans were taken to establish a cooling curve for the piston. The piston temperature was linearly extrapolated back to the time when the engine was stopped. The extrapolation process was repeated after running three, six, ten, and twenty minutes for a total engine running time of thirty-nine minutes.

2. Thermocouple test in engine

The sensor calibration test was conducted by placing the entire engine assembly into an oven to raising the entire piston temperature in specified increments. After the oven Temperature was changed the engine was allowed to soak for 90 minutes to ensure that the interior piston temperature had reached that of the oven. Temperature readings were then Recorded from two K-type thermocouples cemented onto the piston crown and a K-type thermocouple placed inside the oven. A total of eight temperatures were measured extending To 1200°C. Thermocouple temperature variation graph versus time difference.

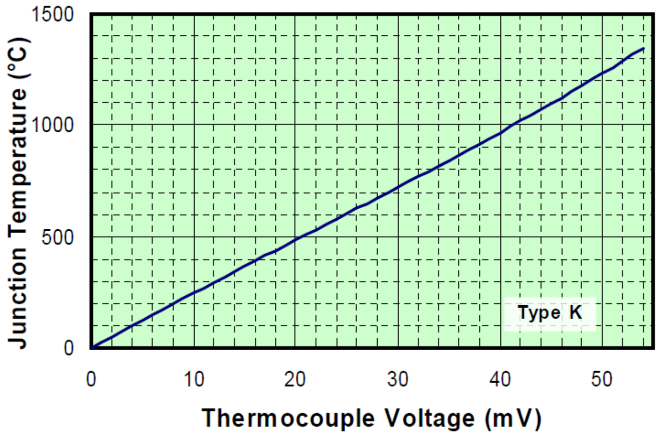

Figure8. Sensitivity of a standard type-K thermocouple, measured junction temperature (°C) versus thermocouple voltage.

Knowing the sensor location is important for future use since the temperature profile can vary greatly over the piston crown area. A piston that had completes the sensor embedding process was sectioned to examine how well the sensor placement differed from the desired location. The piston was cut into four pieces giving a total of eight end views to inspect.

VI CONCLUSION

The thermocouple based fire warning system for piston engine the thermocouple is an invaluable tool to collect and analyse experimental data, having the ability to clearly present real time results, with sensors and probes able to respond to parameters that are beyond the normal range available from most traditional equipment. Thermocouple used for measuring the temperature might have certain limitations in terms of speed, memory and cost. In this work, an attempt has been done to design a PCB board, which is of less cost, portable, very low power consumption, self-contained. It is an efficient thermocouple, which works in real time mode. A step-by-step approach in designing a Microcontroller based system for Temperature measurement has been followed During the course of this project piston temperature was measured in a running internal combustion engine by the use of a thermocouple sensor embedded into the surface of the piston. To accomplish this goal the engine block was modified for optical access to the cylinder and the piston had a groove machined to allow placement of the sensor. The sensor was embedded into the piston surface using a low temperature electroplating process that leaves the thermocouple in a functional condition. The project as reported in this thesis involved only taking piston temperature measurement at only one operating condition. In order to further study engine heat transfer further investigation should be undertaken to examine the effects of various operating parameters. As suggested in other literature the effects of engine speed, load and fuel Mixture are thought to be major influences in piston temperature and should be investigated. While only limited knowledge can be gained by using the current single point temperature measurement it may prove insightful to overall engine heat transfer.

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