An Optimized Design Structure and Multiple Graphical Analysis for Heat Transferring Process of Boiler System Using Android Environment

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***Abstract*— In recent days of technological development in mechanical industries, the Heating process plays major roles for fabricating different parts of the mechanical systems. The properties of these products such as hardening, strength, bearing capacity and density etc., are based on melting point of the system during the process (Heat transfer). The melting point of each metal is different. The measurement and analysis of the heat transfer of the system is very important in fabrication. In market, Lot of measuring devices is available in the form hardware (Thermometer) as well as software tools (ANSYS). All these tools are especially designed for measuring the analysis of the heat process only and also the size, installation process of the tools are of high cost as well as it occupies more space and mobility of the system is difficult. But in modern world all the technological development comes under Smartphone. Thermal management of handheld systems such as smart phones application (GUI) and tablet systems is becoming increasingly challenging due to increasing power dissipation of the older system. This system presents thermal model development of the boiler from an analysis of today's smart phone thermal management schemes and application of these techniques to a tablet system.**

***Indexed Terms*-- Heat transfer, smart phone application and tablet system**

I. INTRODUCTION

In recent days of technological development in mechanical industries, the Heating process plays major roles for fabricating different parts of the mechanical systems. The properties of these products such as hardening, strength, bearing capacity and density etc., are based on melting point of the system during the process (Heat transfer). Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy (heat) between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. Engineers also consider the transfer of mass of differing chemical species, either cold or hot, to achieve heat transfer. While these mechanisms have distinct characteristics, they often occur simultaneously in the same system. Heat conduction, also called diffusion, is the direct microscopic exchange of kinetic energy of particles through the boundary between two systems. When an object is at a different temperature from another body or its surroundings, heat flows so that the body and the surroundings reach the same temperature, at which point they are in thermal equilibrium. Such spontaneous heat transfer always occurs from a region of high temperature to another region of lower temperature, as described by the second law of thermodynamics.

Heat convection occurs when bulk flow of a fluid (gas or liquid) carries heat along with the flow of matter in the fluid. The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer. The latter process is often called "natural convection". All convective processes also move heat partly by diffusion, as well. Another form of convection is forced convection. In this case the fluid is forced to flow by use of a pump, fan or other mechanical means. Thermal radiation occurs through a vacuum or any transparent medium (solid or fluid).

It is the transfer of energy by means of photons in electromagnetic waves governed by the same laws.

II. OBECTIVES OF THE SYSTEM

To Design and analyze the heat transferring process at different stages in boiler system with interfacing and controller units. The interfacing unit is used to provide the link between sensors node in boiler with controller unit. A predesigned program stored in controller for calculating the heat transfer value. The calculated values transfer to smart phone through Bluetooth module.

III. PROPOSED SYSTEM

Hardware: LM 35 transistor (temperature sensor), PIC microcontroller,
HC-05 Bluetooth Module
Software: Android App (Android studio)

Merits:

- Digital system
- Accurate Measurement and analysis
- Modern Advancement
- Mobility
- Free Installation
- Supports all type of smart-phone or tablet system
- Hybrid analysis
- User friendly
- Less memory enough to store large values

IV. HEAT TRANSFER

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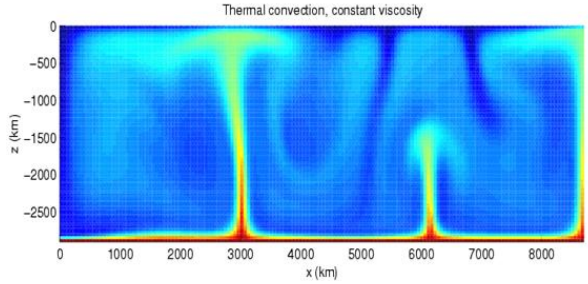

Fig.4.1: Simulation of thermal convection in the Earth's mantle

Heat conduction, also called diffusion, is the direct microscopic exchange of kinetic energy of particles through the boundary between two systems. When an object is at a different temperature from another body or its surroundings, heat flows so that the body and the surroundings reach the same temperature, at which point they are in thermal equilibrium. Such spontaneous heat transfer always occurs from a region of high temperature to another region of lower temperature, as described by the second law of thermodynamics.

Heat convection occurs when bulk flow of a fluid (gas or liquid) carries heat along with the flow of matter in the fluid. The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer. The latter process is often called "natural convection". All convective processes also move heat partly by diffusion, as well. Another form of convection is forced convection. In this case the fluid is forced to flow by use of a pump, fan or other mechanical means.

Thermal radiation occurs through a vacuum or any transparent medium (solid or fluid). It is the transfer of energy by means of photons in electromagnetic waves governed by the same laws.

4.1 Overview:

Heat is defined in physics as the transfer of thermal energy across a well-defined boundary around a thermodynamic system. The thermodynamic free energy is the amount of work that a thermodynamic system can perform. Enthalpy is a thermodynamic potential, designated by the letter "H” that is the sum of the internal energy of the system (U) plus the product of pressure (P) and volume (V). Joule is a unit to quantify energy, work, or the amount of heat. Heat transfer is a process function (or path function), as opposed to functions of state; therefore, the amount of heat transferred in a thermodynamic process that changes the state of a system depends on how that process occurs, not only the net difference between the initial and final states of the process.

Thermodynamic and mechanical heat transfer is calculated with the heat transfer coefficient, the proportionality between the heat flux and the thermodynamic driving force for the flow of heat. Heat flux is a quantitative, vectorial representation of heat-flow through a surface.

In engineering contexts, the term *heat* is taken as synonymous to thermal energy. This usage has its origin in the historical interpretation of heat as a fluid (*Caloric*) that can be transferred by various causes, and that is also common in the language of laymen and everyday life. The transport equations for thermal energy (Fourier's law), mechanical momentum (Newton's law for fluids), and mass transfer (Fick's laws of diffusion) are similar, and analogies among these three transport processes have been developed to facilitate prediction of conversion from any one to the others. Thermal engineering concerns the generation, use, conversion, and exchange of heat transfer. As such, heat transfer is involved in almost every sector of the economy. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes.

4.2 Mechanisms

The fundamental modes of heat transfer are:

Advection

Advection is the transport mechanism of a fluid from one location to another, and is dependent on motion and momentum of that fluid.

Conduction or diffusion

The transfer of energy between objects that are in physical contact. Thermal conductivity is the property of a material to conduct heat and evaluated primarily in terms of Fourier's Law for heat conduction.

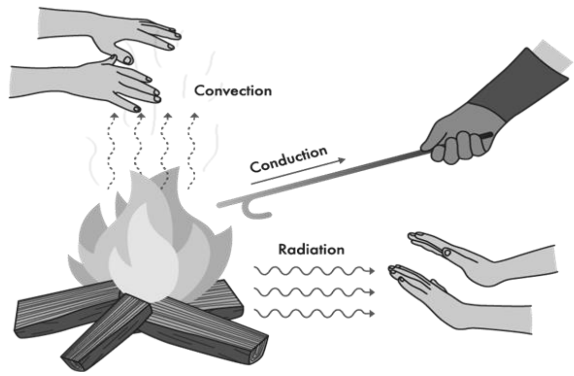

Fig 4.2: Heat Transfer Mechanisms

Convection

The transfer of energy between an object and its environment, due to fluid motion. The average temperature is a reference for evaluating properties related to convective heat transfer.

Radiation

The transfer of energy by the emission of electromagnetic radiation.

4.2.1 Advection

By transferring matter, energy—including thermal energy—is moved by the physical transfer of a hot or cold object from one place to another. This can be as simple as placing hot water in a bottle and heating a bed, or the movement of an iceberg in changing ocean currents. A practical example is thermal hydraulics. This can be described by the formula:

$$Q=v\rho c\rho \Delta T$$

Where Q is heat flux (W/m²), ρ is density (kg/m³), cρ is heat capacity at constant pressure (J/kgK), ΔT is the change in temperature (K), v is velocity (m/s).

4.2.2 Conduction

On a microscopic scale, heat conduction occurs as hot, rapidly moving or vibrating atoms and molecules interact with neighboring atoms and molecules, transferring some of their energy (heat) to these neighboring particles. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from one atom to another. Conduction is the most significant means of heat transfer within a solid or between solid objects in thermal contact. Fluids—especially gases—

are less conductive. Thermal contact conductance is the study of heat conduction between solid bodies in contact. The process of heat transfer from one place to another place without the movement of particles is called conduction. Example: Heat transfer through Metal rods. Steady state conduction is a form of conduction that happens when the temperature difference driving the conduction is constant, so that after an equilibration time, the spatial distribution of temperatures in the conducting object does not change any further. In steady state conduction, the amount of heat entering a section is equal to amount of heat coming out.

Transient conduction occurs when the temperature within an object changes as a function of time. Analysis of transient systems is more complex and often calls for the application of approximation theories or numerical analysis by computer.

4.2.3 Convection

The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer. The latter process is often called "natural convection". All convective processes also move heat partly by diffusion, as well. Another form of convection is forced convection. In this case the fluid is forced to flow by using a pump, fan or other mechanical means. Convective heat transfer, or convection, is the transfer of heat from one place to another by the movement of fluids, a process that is essentially the transfer of heat via mass transfer. Bulk motion of fluid enhances heat transfer in many physical situations, such as (for example) between a solid surface and the fluid.[10] Convection is usually the dominant form of heat transfer in liquids and gases. Although sometimes discussed as a third method of heat transfer, convection is usually used to describe the combined effects of heat conduction within the fluid (diffusion) and heat transference by bulk fluid flow streaming. The process of transport by fluid streaming is known as advection, but pure advection is a term that is generally associated only with mass transport in fluids, such as advection of pebbles in a river. In the case of heat transfer in fluids, where transport by advection in a fluid is always also accompanied by transport via heat diffusion (also known as heat conduction) the process of heat convection is understood to refer to the sum of heat transport by advection and diffusion/conduction.

Free, or natural, convection occurs when bulk fluid motions (streams and currents) are caused by buoyancy forces that result from density variations due to variations of temperature in the fluid. *Forced* convection is a term used when the streams and currents in the fluid are induced by external means—such as fans, stirrers, and pumps—creating an artificially induced convection current.

4.3 DEVICES

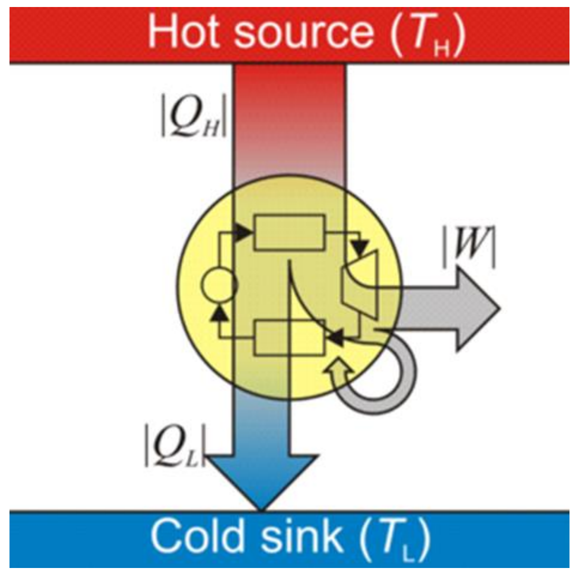

Fig4.3: Schematic flow of energy in a heat engine.

A heat engine is a system that performs the conversion of a flow of thermal energy (heat) to mechanical energy to perform mechanical work.

A thermocouple is a temperature-measuring device and widely used type of temperature sensor for measurement and control, and can also be used to convert heat into electric power. A thermoelectric cooler is a solid state electronic device that pumps (transfers) heat from one side of the device to the other when electric current is passed through it. It is based on the Peltier effect. A thermal diode or thermal rectifier is a device that causes heat to flow preferentially in one direction.

4.3.1 Heat exchangers

A heat exchanger is used for more efficient heat transfer or to dissipate heat. Heat exchangers are widely used in refrigeration, air conditioning, space heating, power generation, and chemical processing. One common example of a heat exchanger is a car's radiator, in which the hot coolant fluid is cooled by the flow of air over the radiator's surface.

V. SYSTEM FUNCTION

5.1 FUNCTIONAL BLOCK DIAGRAM

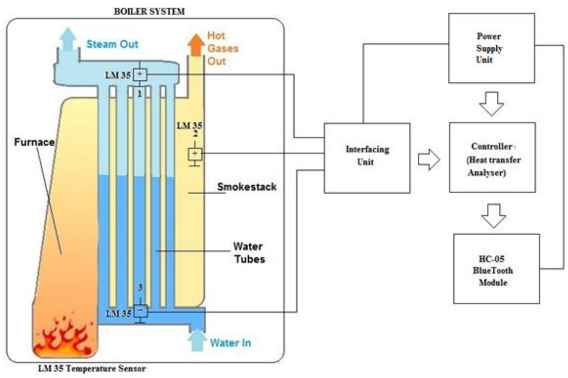

Fig 5.1 functional block diagram of the system

This system consists of boiler, LM35 transistor, IC MAX232, PIC16F877A microcontroller and HC-05 Bluetooth module. The water contents applied to input of the boiler and water flow through pipe inside of the boiler. The furnace produces the heat transfer mechanisms when it is heated. The stream produces when the heating point reaches its saturation point. The LM 35 fixed in three different places in or out side of the boiler system. One is fixed near in water input stage, second one is fixed in furnace and another one is fixed in point of hot gases out. The LM 35 is a transistor which works as a temperature sensor. The LM35 produces the electrical output according to heat input.

The output of the LM 35 is applied to the input of the ADC (Analog to digital Convertor) port of the PIC 16F877A microcontroller through interfacing units. The ADC port converts the analog (Electrical) signal into digital signal. The Embedded program designed and stored into PIC 16F877A controller which is used to calculate the converted digital signal to heat transfer values. These values are communicating from controller TX (transmitter) Pin to Smartphone or tablet system using through HC-05 Bluetooth (BT) module. Bluetooth module communicates the signal within the distance of 15 feet’s. 2.4GHZ ISM band can be used in BT module for communication. The IC MAX232 is located between controller and BT module which is used to compensate the voltage level between controller as well as BT module.

Transferred values are received from controller unit and it is viewed in Smartphone monitor using mobile phone APP (application) developed by using android studio software. Three different temperature node values can be monitored in single window. The Results of the values can be viewed in the form of graphical analysis as well as numerical readings.

Power supply Unit is designed to produce regulated +5V for working of the system

5.1.1 Monitoring System

Android OS (Operating System) based any smart phone can be used for monitoring this system. The example graphical analysis model obtained by smart-phone is given below:

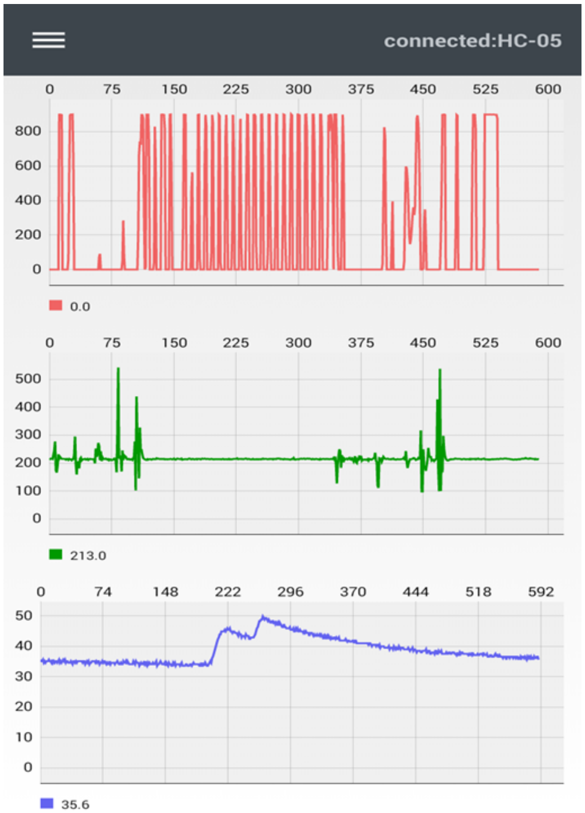

Fig 5.2: Example graphical analysis model

5.1.2 Specifications

Hardware features

- Typical -80dBm sensitivity
- Up to +4dBm RF transmit power
- Low Power 1.8V Operation ,1.8 to 3.6V I/O
- PIO control
- UART interface with programmable baud rate
- With integrated antenna
- With edge connector

Software features

- Default Baud rate: 38400, Data bits: 8, Stop bit: 1, Parity: No parity, Data control: has. Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.
- Given a rising pulse in PIO0, device will be disconnected.
- Status instruction port PIO1: low-disconnected, high-connected;
- PIO10 and PIO11 can be connected to red and blue led separately. When master and slave are paired, red and blue led blinks 1time/2s in interval, while disconnected only blue led blinks 2times/s.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PINCODE:"0000" as default
- Auto-reconnect in 30 min when disconnected as a result of beyond the range of connection.

VI. EXPERIMENTAL RESULTS

6.1 BOILER CONTENT: Water (H_2O)

Starting point of the measurements: 0 to 32^0C (including room temperature)

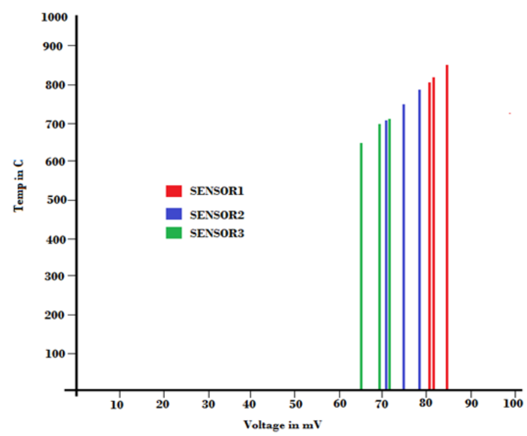

Fig: 6.1Graphical analysis of Voltage Vs Temperature of boiler

TABLE: 6.1 Heat transfer analysis

SENSOR1(TOP)		SENSOR2 (MIDDLE)		SENSOR3(BOTTOM)	
Volt (mV)	Heat in ^{0}C	Volt (mV)	Heat in ^{0}C	Volt (mV)	Heat in ^{0}C
85.0	850	78.0	780	72.0	720
82.2	822	75.5	755	69.8	698
81.7	817	71.0	710	65.0	650

Scale Factor : 10.0mV/1^0C

Heater Type : Electrical

Input Voltage : 240V AC

6.2 Boiler Dimension:

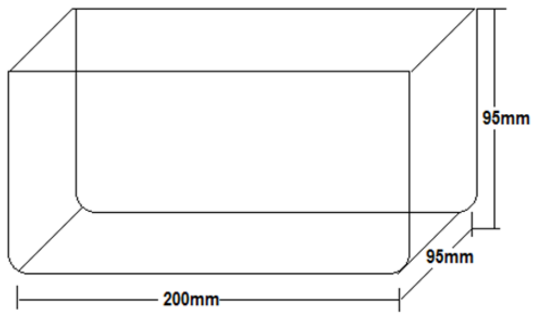

Fig: 6.2 Line diagram of Boiler

CONCLUSION

This project has determined that useful heat transfer analysis from boiler gases or water stream boiling has potential using smart-phone, and can be economic in comparison with other environmentally positive investments. This positive conclusion is, however, qualified as the analysis here is theoretical and based on assumptions that would need further verification. Our conclusion is therefore that further test work is justified to understand the impact of the assumptions, rather than directly recommending implementation. User motivation and safe operation concerns, with the associated health and safety risks, are more likely to be limitations to future development than the fundamental market conditions. This project report has been completed successfully with the analysis done.

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