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Design and Fabrication of Heat Exchangers

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ABSTRACT:

At present the burning issue around the world is the energy crisis due to the lack of non- renewable energy sources , which gives a sound impact on the usage of the energy liberated to the atmosphere (Waste heat) , and all the experiments are going around efficient usage of the available energy into useful work. Huge amount of energy is rejected from industries, manufacturing plants as a waste heat into environment which may lead to increase the environmental global warming.currently it has been identified that there is a lot of unused heat energy which is released into atmosphere from the moulded bars while cooling to room temperature in the Steel Plant.

The aim of this project is to convert the waste heat that is available at the steel plant into useful work. This project works on the principle of seebeck effect and it is one of the direct energy conversion techniques. The Thesis focuses on the design, fabrication of Heat Exchanger in order to produce electricity by using seebeck principle. The analytical work is carried out by using NI lab View Software for calculating temperatures which varies by time to achieve useful work.

KEY WORDS:

Seebeck effect, Peltier effect, Thermoelectric Generators Theory, Fabrication, Induction Heat Exchangers, Aurdino.

I. INTRODUCTION:

As we talk about the waste heat, lots of heat is simply exhausted into the sink i.e., the atmosphere which can be utilized in many ways.Industrial waste heat refers to energy that is generated in industrial processes without being put to practical use. Sources of waste heat include hot combustion gases discharged to the atmosphere, heated products exiting industrial processes, and heat transfer from hot equipment surfaces. The exact quantity of industrial waste heat is poorly quantified, but various studies have estimated that as much as 20 to 50% of industrial energy consumption is ultimately discharged as waste heat. While some waste heat losses.

Industrial processes are inevitable; facilities can reduce these losses by improving equipment efficiency or installing waste heat recovery technologies. Waste heat recovery entails capturing and reusing the waste heat in industrial processes for heating or for generating mechanical or electrical work. Example uses for waste heat include generating electricity, preheating combustion air, preheating furnace loads, absorption cooling, and space heating.

A heat exchanger is a device which is used to transfer heat from a hot body to a cold body. Heat recovery technologies frequently reduce the operating costs for facilities by increasing their energy productivity. Many recovery technologies are already well developed and technically proven; however, there are numerous applications where heat is not recovered due to a combination of market and technical barriers.

As discussed below, various sources indicate that there may be significant opportunities for improving industrial energy efficiency through waste heat recovery. A comprehensive investigation of waste heat losses, recovery practices, and barriers is required in order to better identify heat recovery opportunities and technology needs. Such an analysis can aid decision makers in identifying research priorities for promoting industrial energy efficiency.

II. LITERATURE REVIEW:

C. Ramesh Kumar Ankit Sonthalia and **Rahul goel:**

Presented EXPERIMENTAL STUDY ON WASTE HEAT RECOVERY FROM AN INTERNAL COMBUSTION ENGINE USING THERMOELECTRIC TECHNOLOGY has investigated major part of the heat supplied in an internal combustion engine is not realized as work output, but dumped into the atmosphere as waste heat. If this waste heat energy is tapped and converted into usable energy, the overall efficiency of an engine can be improved .The percentage of energy rejected to the environment through exhaust gas which can be potentially recovered is approximately 30-40% of the energy supplied by the fuel depending on engine load.

L.Che F. Meng,F. Sun has done project on Maximum power and efficiency of an irreversible thermo electric generator with a generalized heat transfer law by an advanced model of irreversible thermoelectric generator with a generalized heat transfer law is established based on finite time thermodynamics. The generalized heat transfer law represents a class of heat transfer laws including Newtonian heat transfer law, linear phenomenological heat transfer law, radiative heat transfer law, Dulong-Petit heat transfer law, generalized convective heat transfer law and generalized radiative heat transfer law.

Ajitkumar N. Nikamand Dr. Jitendra has done a Review on use of Peltier Effects by they studied that In recent years, with the increase awareness towards environmental degradation due to the production, use and disposal of Chloro Fluoro Carbons (CFCs) and Hydro Chlorofluorocarbons (HCFCs) as heat carrier fluids in conventional refrigeration and air conditioning systems has become a subject of great concern and resulted in extensive research into development of novel refrigeration and space conditioning technologies.

P.ArunkumarP.Iswarya,S.SuprajaP.RajaRajan and **G.Balajiha** has presented a project on A New Concept of Energy Recovery and Cooling Solution for Integrated Circuit Heat Using Thermoelectric Technology by has done a project on Energy recovered from the waste heat of IC's might be utilized for providing backup electricity in an emergency situation or providing electricity to drive electrical components. Thermoelectric generators are solid-state energy converters that combine thermal and electrical properties to convert heat into electricity or electrical power directly into cooling. Effective energy recovery may improve energy efficiencies and also life of IC and the equipment.

N. Pradeep Kumar S. Suseel Jai Krishnan and**N. SakthiThasan's** Effects of fouling in EGR Coolers in Automobiles by 20 per cent of global greenhouse gas emissions such as CO2 NOx and HC which have not been burned completely in the engine. In particular, 55 per cent of globally emitted NOx which is more harmful to the environment than CO2 is produced by the automotive industry alone. Strict emission standards are now in place that set specific limits to the amount of pollutants that can be released into the environment. The widely used measure to reduce NOx emissions in diesel engines is to return part of the exhaust gas to the intake of the engine. This is usually done through via a heat exchanger known as exhaust gas recirculation cooler. However EGR coolers are subject to severe fouling such that their thermal efficiency can drop by as much as 30 per cent within a very short period of time. More importantly, the deposit layer is a blend of particulate matter and sticky heavy hydrocarbons that are very difficult to remove from the heat exchanger surfaces. The present study addresses this problem and provides a review on the effects and R & D activities happening to mitigate fouling of EGR cooler.

III. WORKING PRICIPLE:

a. Seebeck effect:

As we discussed earlier waste heat is available in the steel plant of Visakhapatnam in the form of the temperature of the molten material which is around

1700^0 c to 1950^0c. So this amount of heat energy is wasted during the process of cooling the molten metal which is drawn into large structures or bars after moulding. The temperature at the steel plant is relatively high, in order to represent the high temperature atmosphere that is available at the steel plant I am using an induction spring which produces the heat energy by using electric energy based on the principle of resistance. The heat energy liberated by the ignition coil is equivalent to the heat liberated by the cooling molten metal at steel plant. By using the peltier module and the thermo electric generator we can produce the electricity by the principle of see-beck effect.

b. Thermoelectric Generators Theory:

A Thermoelectric generator (TEG) is a device that converts heat directly into electrical energy through a phenomenon called the Seebeck effect. Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power. Another application is radioisotope thermoelectric generators which are used in space probes, which has the same mechanism but use radioisotopes to generate the required heat difference. They are primarily used as remote and off-grid power generators for unmanned sites. They are the most reliable power generator in such situations as they do not have moving parts, work day and night, perform under all weather conditions, and can work without battery backup.Thermoelectric power generators consist of three major components: thermoelectric materials, thermoelectric modules and thermoelectric systems that interface with the heat source.

Thermoelectric materials generate power directly from heat by converting temperature differences into electric voltage. These materials must have both high electrical conductivity (σ) and low thermal conductivity (κ) to be good thermoelectric materials. Having low thermal conductivity ensures that when one side is made hot, the other side stays cold, which helps to generate a large voltage while in a temperature gradient. The measure of the magnitude of electrons flow in response to a temperature difference across that material is given by the Seebeck coefficient (S).

c. Peltier effect:

When DC voltage is applied to the module, the positive andnegative charge carriers in the pellet array absorb heat energyfrom one substrate surface and release it to the substrate at theopposite side. The surface where heat energy is absorbedbecomes cold; the opposite surface where heat energy isreleased becomes hot. Reversing the polarity will result inreversed hot and cold sides.

IV. WORKING:

By considering the waste heat that is available in the steel plant which can be best utilized for production of electricity by using the see beck effect. A device named thermoelectric generator is utilized for this purpose. TEC1-12706 Heat sink Thermoelectric Cooler Cooling Peltier Plate Module 12V 60W Features: - Get ice cold in minutes or heat to boiling by simply reversing the polarity. Used for numerous applications from CPU coolers to alternate power sources, or even for your own custom car, drinking water warmer/cooler.

V. PARTS AND ITS WORKING: DESIGN & FABRICATION

Design Considerations:

The fabricated heat exchanger is of dimensions

14 inches in height

9 inches in length

These dimensions are taken from a heat exchanger that is available at VIZAG STEEL PLANT; the parameters for the design of the heat exchanger are the length, breadth and height. The most important dimension is the distance between the two heat producing induction coils that plays a vital role in the formation of hot side for the thermo couple. In the fabrication of the prototype two heat exchangers are used in which one of the heat exchanger is placed on the left side and the other one is placed on the right side. The distance between both the coils is 9 inches in which if the distance between the coils is increased then the heat transferred may be low and the required level of temperature is not attained. On the other hand if the length is low then it may lead to spoil the components of the prototype because of the excessive temperature

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raise within very short span of time. The outer diameter of the heat exchanger is 5.8" inches.One side of the induction coil holder consists of a peltier module and on the other side, the induction coil which makes one side of the peltier as hot and the other side of the peltier is free to the open atmosphere which acts as a cold junction that can creates the temperature difference in the peltier module which creates the electric power. At the top of the prototype an integrated cooling fan is fitted whose diameter is 4.8 inches. It is rotated with the energy produced by the peltier`s. A sensor which is used to sense the temperature is placed inside the heat exchanger; it is synchronized with the N.I. Lab View software with the aid of Arduino

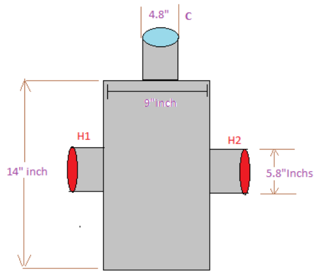

Fig:1 Heat Exchanger Prototype

Fabrication:

The metal taken here is a sheet metal and subjected to perform the following sheet metal operations in order to fabricate the heat exchanger body. The required properties of the sheet metal taken are: Thickness : 42MM

Thermoelectric Generator:

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TEC1-12706 Heat sink Thermoelectric Cooler Cooling Peltier Plate Module 12V 60W Features: - Get ice cold in minutes or heat to boiling by simply reversing the polarity, - Used for numerous applications from CPU coolers toalternate power sources, or even for your own custom car drink warmer/cooler. - Since they consist primarily of semiconductor material sandwiched between ceramic plates and have no moving parts -These devices must be used in conjunction with a heat sink to avoid burned - Each device is full inspected and tested - Fitted with 6-inch insulated leads Technical Specifications: -Model: TEC1-12706 -Size: 40mm x 40mm x 4mm -Operates from 0~15.2V DC and 0~6A -Operates Temperature: -30 to 70 -Max power consumption: 60 Watts -Original box: NO -Net weight: 22g -Package weight: 31g

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AURDINO:

An Arduino board consists of an Atmel 8-bit microcontroller with complementary components to facilitate programming and incorporation into other circuits. Official Arduino have used the mega AVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. Most boards include a 5 volt linear regulator and a 16 MHz crystal oscillator or ceramic resonator in some variants.

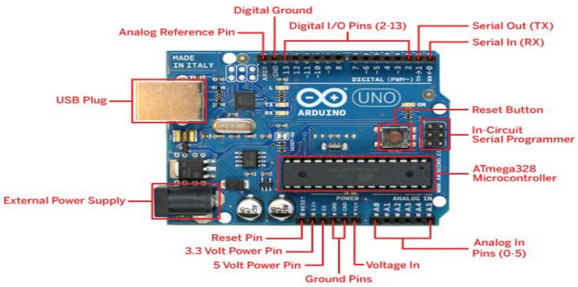


Fig:2Aurdino

An Arduino microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chipflash memory, compared with other devices that typically need an external programmer. This allows an Arduino to be used by novices and experts alike without having to go through the difficulties first faced by many when using electronics by allowing the use of an ordinary computer as the programmer. At a conceptual level, when using the Arduino software stack, all boards are programmed over an RS-232 serial connection, but the way this is implemented varies by hardware version.

Current Arduino boards are programmed via USB, implemented using USB-to-serial adapter chips such as the FTDI FT232. When used with traditional microcontroller tools instead of the Arduino IDE, standard AVR ISP programming is used. Arduino board provides 14 digital I/O pins, six of which can produce pulse-width modulated signals, and other six analog inputs. The output or inputs can be taken from the boards or given to the board using convenient connectors. Both digital and analog inputs and outputs are available in all Arduino boards.

The arduino boards can also communicate with other devices using standard communication ports like USART, IIC, and USB etc.

PELTIER:

A typical thermoelectric module consists of an array of BismuthTelluride semiconductor pellets that have been “doped” so that onetype of charge carrier– either positive or negative– carries the majority of the current. The pairs of P/N pellets are configured so thatthey are connected electrically in series, but thermally in parallel.Metalized ceramic substrates provide the platform for the pelletsand the small conductive tabs that connect them.

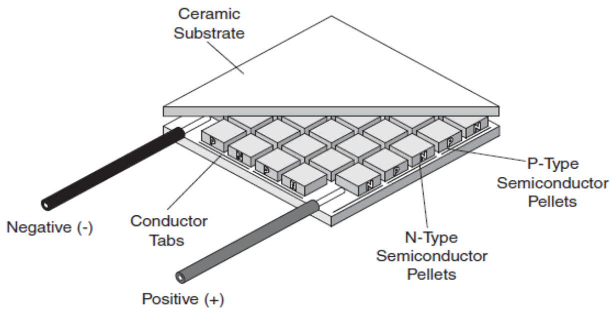
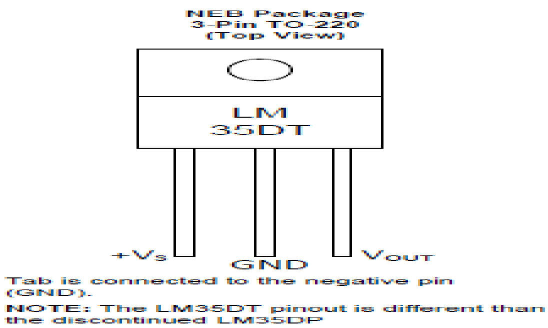


Fig:3 peltier

Temperature sensor:



The temperature sensor used is LM 35. The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly- proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C

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over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. TheLM35 device is rated to operate over a −55°C to150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

Heat exchangers:

The induction exchanger is used for adjustable heating

Fig:4Heatexchangers

Different heat can be adjusted for boiling, stewing. It also takes minimal time to cool. Electrostatic induction is a redistribution of electrical charge in an object, caused by the influence of nearby charges. In the presence of a charged body, an insulated conductor develops a positive charge on one end and a negative charge on the other end. Induction was discovered by British scientist John Canton in 1753 and Swedish professor Johan Carl Wilcke in 1762.Electrostatic generators, such as the Wimshurst machine, the Van de Graff generator and the electrophorus, use this principle.

Fig:5 multimeter

Due to induction, the electrostatic potential (voltage) is constant at any point throughout a conductor. Induction is also responsible for the attraction of light nonconductive objects, such as balloons, paper or Styrofoam scraps, to static electric charges. Electrostatic induction should not be confused with electromagnetic induction.

Multi meter:

Inspection is done on peltier module by preparing the hot and cold junctions. It is shown in the Figure. the ammeter reading and the figure explains you the testing of the induction coil while connected. The figure 5.5 indicates the voltage reading in the multimeter.

RESULTS:

The temperature values that are available time to time are drawn in a graph and table in which time in seconds along the x-axis and temperature along the y-axis. On studying the graph.

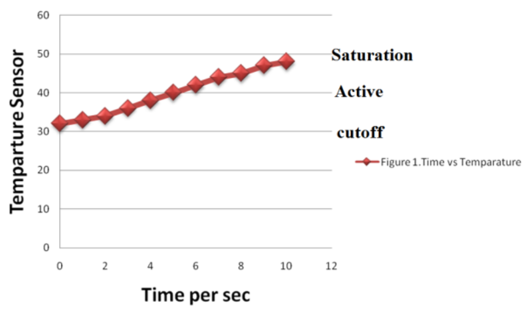

Fig:6 Multimeter with Heat exchanger

Is noted that the minimum temperature that is noticed is 30^0c is called as the cutoff temperature. The temperature 40^0c called as the active temperature and 50^0c is called as the saturation temperature.

Time vs Temperature graph:

Temp vs Time table:

S.No	Time	Temperature
1	0	32
2	1	33
3	2	34
4	3	36
5	4	38
6	5	40
7	6	42

VI. ADVANTAGES:

High heat transfer efficiency especially in gas treatment.Larger heat transfer area.Approximately 5 times lighter in weight than that of shell and tube heat exchanger.

VII. CONCLUSION:

It has been identified that there are large potentials of energy savings through the use of waste heat recovery technologies. In this work the electricity of 10v is produced and is utilized to run a computer integrated cooling fan which is the main motto of this work. From the above work it may consider as peltier and seebeck effects are the one of the most promising concepts to achieve effective use of waste heat recovery from industries, plants etc.

The aim of this project is achieved by conversion of waste heat that is available at the steel plant into useful work. It is also observed that the voltage produced by the peltiers in the multimeter and that energy is either stored or it can be directly utilized. Apart from the utilization of heat, this project also deals with the continuous representation of the temperature available at any point of time by using a temperature sensor. This validates the project practically.

FUTURE SCOPE:

Above work shows the utilization of the waste heat into generating electricity. At present the work was done up to 10V only by using a small prototype. By studying the proper design and arrangements it can also be employed for all industries, plants & etc. But it is based on temperature limits & ranges.

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