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Waste Heat Recovery and Conversion of Electricity Using Thermo Electric Generator

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***Abstract*— The increasing global energy crisis and depletion of non-renewable resources necessitate the development of alternative energy solutions. A significant portion of energy is lost as waste heat in industrial processes, particularly in steel plants, where large amounts of heat are released into the atmosphere during the cooling of molded bars. This project aims to harness this waste heat and convert it into useful electrical energy using a Thermo electric Generator (TEG) based on the See-beck effect, a direct energy conversion technique and cooling the surroundings by using of thermo electric cooler(TEC) by increasing the efficiency of machinary.**

Key words: Induction heat exchangers, Thermo electric generator (TEG), Thermo electric cooler(TEC),Exhaust fan, Temperature sensor.

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.

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. That lot waste heat is recovered and conversion into useful electricity using Thermo electric generator and converting cooling effect.

2. LITERATURE SURVEY

C.Rameshkumar AnkitSonthalia and **Rahul goel**[1] 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 .

Sumeet Kumar, Stephen d.heister, Xianfanxu and **James r.salvador and Gregory p.meisner**[8]has studied on Thermoelectric Generators for Automotive Waste Heat Recovery A numerical model has been developed to simulate coupled thermal and electrical energy transfer processes in a thermoelectric generator (TEG) designed for automotive waste heat recovery systems. This model is capable of computing the overall heat transferred, the electrical power output, and the associated pressure drop for given inlet conditions of the exhaust gas and the available TEG volume.

José Rui Camargo and **Maria Claudia Costa de Oliveira**[10]has done project on the Seebeck effect was first observed by the physician Thomas Johann Principles of Direct Thermoelectric Conversion Seebeck, in 1821, when he was studying thermoelectric phenomenon. It consists in the production of an electric

power between two semiconductors when submitted to a temperature difference. An electrical current is produced, proportional to the temperature gradient between the hot and cold sides. The temperature differential across the converter produces direct current to a load producing a terminal voltage and a terminal current. There is no intermediate energy conversion process. For this reason, thermoelectric power generation is classified as direct power conversion.

3. METHODOLOGY

Design consideration:

The distance between the two induction coils (9 inches) is crucial for heat transfer. Increasing the gap reduces heat transfer, while a shorter gap may cause overheating and damage components.

Two heat exchangers (5.8-inch outer diameter) are positioned on opposite sides. A Peltier module is attached to one side of the induction coil holder, where one side becomes hot while the other remains exposed to air, creating a temperature difference that generates electricity.

A 4.8-inch cooling fan is mounted at the top, powered by the Peltier modules. A temperature sensor inside the heat exchanger for regular monitoring.

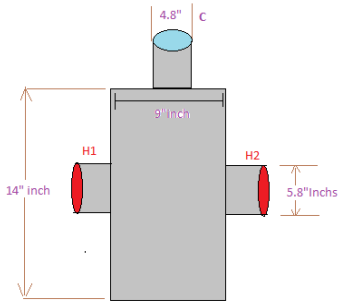


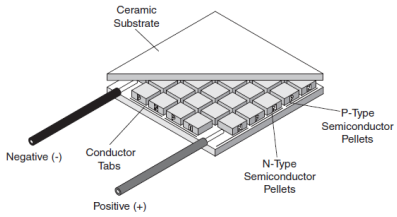
Fig: Heat exchanger prototype

Specifications:

The TEC1-12706 Thermoelectric Cooler (Peltier Plate Module) is a versatile 12V device that can cool to ice-cold temperatures or heat to boiling by reversing polarity. It is ideal for applications like CPU cooling, alternate power sources, and custom drink warmers/coolers. The module consists of semiconductor material sandwiched between ceramic plates, with no moving parts, requiring a heat sink to prevent overheating. It operates between 0-15.2V DC and 0-6A, with a temperature range of -30°C to 70°C and a maximum power consumption of 60W.

Thermo Electric Generator:

A Thermoelectric generator (TEG) is a device that converts heat directly into electrical energy through a phenomenon called the See beck effect.



Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power.

Fig: Thermo electric generator

See-Beck effect:

The See-beck effect converts a temperature difference into an electrical voltage using two different conductive materials (metals or semiconductors).

Working Principle:

When one junction is heated while the other remains cool, charge carriers gain energy and start moving. Electrons (in metals) or charge carriers (in semiconductors) move from hot to cold regions. This movement creates an electric potential difference (voltage) across the materials. The generated voltage can be measured and used in various applications.

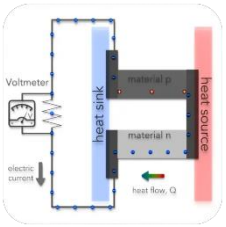


Fig : Working of see beck effect

Thermo Electric Cooler (TEC):

A thermoelectric cooler (TEC) uses the Peltier effect to transfer heat from one side to the other. It consists of two thermoelectric materials (p-type and n-type)

connected electrically. When an electric current flows, heat is absorbed on one side (cold side) and released on the other (hot side). Reversing the current reverses the heat transfer. TECs are compact, reliable, and require minimal maintenance, making them ideal for cooling electronics, medical devices, and other applications requiring precise temperature control.

Heat Exchanger:

A heat exchanger is a device designed to transfer heat between two or more fluids without mixing them. These fluids can be gases, liquids, or a combination of both. Heat exchangers are widely used in industries such as HVAC, power plants, automotive, and chemical processing to efficiently regulate temperatures in various systems.

The basic function of a heat exchanger is to allow heat from one fluid to pass to another, usually through a solid barrier (such as metal) that conducts heat but prevents the fluids from mixing. The efficiency of a heat exchanger depends on factors such as the surface area for heat transfer, the temperature difference between the fluids, and the thermal conductivity of the materials involved.

Induction heat exchangers

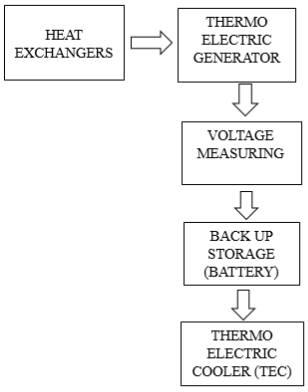
Induction heat exchangers are a type of heat transfer device that uses induction heating to transfer heat between fluids or surfaces. Unlike traditional heat exchangers that rely on conduction and convection, induction heating involves the generation of heat

Fig : Induction heat exchangers

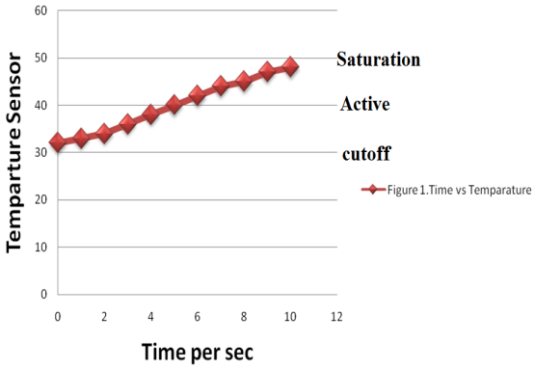
through electromagnetic induction, where an alternating current (AC) passes through a coil, creating a magnetic field that induces eddy currents in a metal or conductive material. These eddy currents cause localized heating, which can be used for heat transfer.

Block diagram

The Block Diagram Explains clear picture of connection in [1].Structural diagram explain in



graphical module the junction and propeller connection at[2].Placing the thermo electric generator works on see-beck effect or Peltier effect. [3].The



voltage measuring and regenerator of battery and signal graphs is measured in Lab view with temperature sensor.[4]. Thermo electric cooler (TEG) converts the electrical energy into cooling effect of surroundings.

4. RESULTS AND DISCUSSIONS

Time vs temperature Graph :

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

the graph it is noted that the minimum temperature that is noticed is 30^0c is called as the cutoff temperature. The temperature 40^0c is called as the active temperature and 50^0c is called as the saturation temperature. To produce the potential difference that means voltage is 8V to 12V in above the temperature difference.

5.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 8v to 12v 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 see beck effects are the one of the most promising concepts to achieve effective use of waste heat recovery from industries, plants etc.

6. FUTURE SCOPE

Above work shows the utilization of the waste heat into generating electricity. At present the work was done up to8V to 12V 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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