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Evolution of Waste Heat Power Generation in Industries

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Abstract: *Recently, there has been a greater emphasis on the global issue of rapid economic development, relative energy scarcity, waste heat from internal combustion engines, and environmental degradation. About 30 to 40 percent of the heat that is fed into the engine in the form of fuel is transformed into mechanical work that is beneficial. Waste heat must be converted into productive activity since the leftover heat is released into the atmosphere through engine cooling systems and exhaust gasses, which causes entropy to grow and significant environmental contamination. As waste heat recovery methods like thermoelectric generators (TEGs) are developed, they have emerged as a promising green alternative technology because of their unique advantages.*

Keywords: thermoelectric generators

I. INTRODUCTION

Over the past century, internal combustion engines have been the main source of power for cars and other vehicles. In order to reduce fuel usage, engines are becoming more sophisticated due to rising fuel prices and worries about reliance on foreign oil[2].

In this project, we are using heat energy as a non-traditional approach to generate electrical power. These days, non-traditional energy methods are crucial to our country. The process of transforming mechanical energy into electrical energy is an example of unconventional energy use. A mechanical arrangement is made in this project. This system is dependable and efficient due to the use of embedded technologies. Faster and more dynamic control is possible with a micro controller. The system is easy to use thanks to the liquid crystal display (LCD). The Arduino controller, which manages every function, is the central component of the circuit.

Heat energy is transformed into electrical energy in this project. A fan will run on this energy, and a battery will store the energy. In order to drive AC/DC loads, the control mechanism carries 12V, a unidirectional current controller, and an A.C. ripple neutralizer. The battery supply will then flow to the inverter. The inverter is linked to the battery. The 12 volt D.C. is converted to 230 volt A.C. with this inverter. The loads are activated using this 230 volt A.C. voltage.

To deliver power to the circuits, we also use a traditional battery charging mechanism. The TEP Transducer is being used in this research.An apparatus that transforms one type of energy into another is called a transducer. This encompasses mechanical, electrical, thermal, and light energy as well. Any device that converts energy is referred to as a transducer, even though the term typically implies the usage of sensors or detectors[1].

FEATURES OF TEG

- They operate silently and are incredibly dependable—they usually have over 100,000 hours of steady-state operation. because they need significantly less maintenance because they don't have any mechanical moving parts
- They are easy to use, portable, and secure.
- They are little and very weightless.
- hey are able to function at high temperatures.
- They work well for remote and small-scale applications.
- They don't harm the environment

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- They are independent of position[3]

II. EXPERIMENTAL SETUP

Power generation from waste of industries

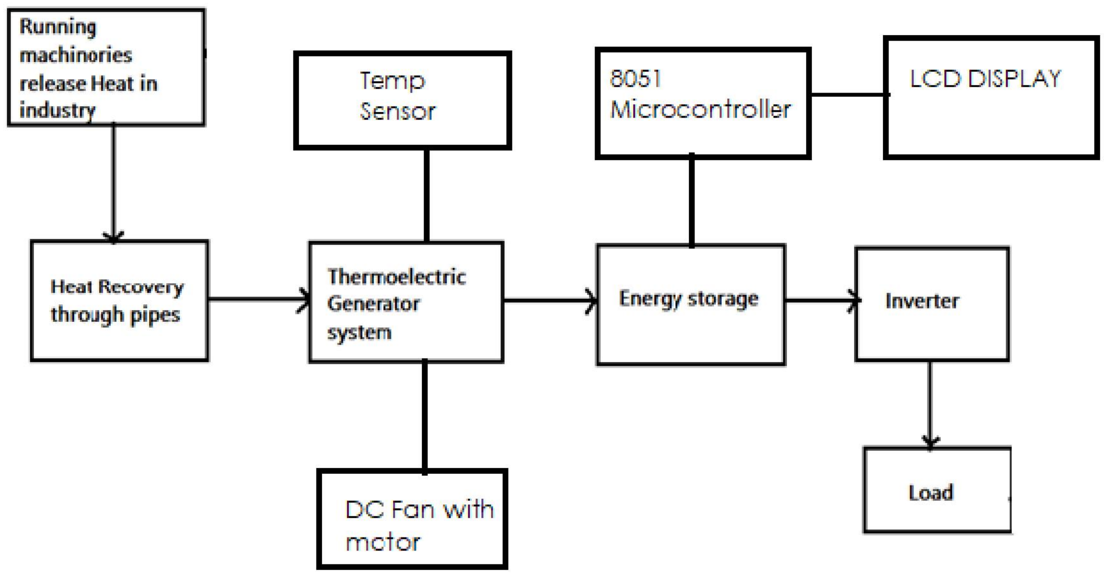

Fig 2.1:- Block Diagram of system

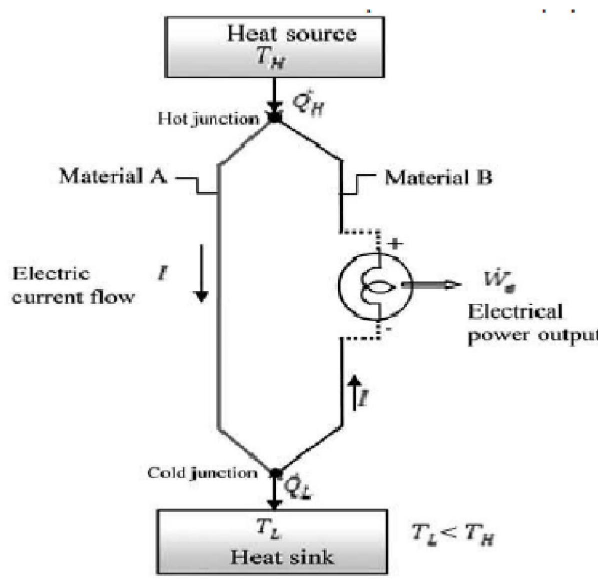

Fig 2.2:- Working Principle

One hot side and one cold side make up TEG. A current will flow through the circuit as a result of the hot side's higher temperature pushing electrons from the n-type leg toward the cold side's lower temperature. These electrons will then traverse the metallic connection and enter the p-type leg. The diffusion of charge carriers will create a constant heat current and, consequently, a constant electrical current if the temperature differential is maintained at a constant level[3].

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- The process of transforming mechanical energy into electrical energy is an example of unconventional energy use. An arrangement for electricity generating is established in this project. This method is dependable and efficient due to its use of the thermoelectric principle.
- Machines in every industry run constantly to produce goods. A significant amount of heat is released. This is heat waste. We generated energy by using this waste heat. We can also reduce some air pollution in this way.
- Heat is wasted through a machine-executed heat pipe when TEG is used in conjunction with a heat sink module. TEG then begins transforming thermal energy into electrical energy simultaneously. With the aid of the system's temperature sensor, we can quantify this heat.
- To show the flow and transformation of thermal energy into electrical energy, a single DC fan is connected to the system. With an increase in temperature, the fan's flow also increases.
- Batteries are used to store generated electrical energy. The inverter uses this stored energy to change DC into AC.
- AC load is obtained at the output. In the same industry, this AC load is used to run many loads, such as fans, air conditioners, lights, etc[4].
- Additionally, we connected an 8051 microprocessor (AT89S52) with an LCD display to gauge the voltage stored and left in the battery.
- The entire system functions in this manner. Begin with the waste of heat that is released throughout the production process in industry. Heat is then transformed into electrical power. indication of electricity conversion via a DC motor and fan. Electricity is stored in batteries. using an inverter to convert DC voltage to AC voltage. A microcontroller is fitted to display the battery's voltage. Lastly, the inverter is connected to the AC load.
- How much heat waste can we use if such a technology is used in the automotive industry? Additionally, the issue of vehicle-induced air pollution was reduced.

COMPONENTS SPECIFICATION :-

- Thermoelectric plate
- Exhaust fan with Aluminum heat sink
- Silencer
- Heat source (Engine considered device)
- DC motor with fan
- Battery
- Inverter module
- Temperature sensor
- Controller board (8051 controller)
- LCD display (16*2)
- wiring
- switches
- LED bulb
- Metallic Frame
- connector circuit board
- Adapter

NECESSITY OF TEG (THERMO ELECTRICAL GENERATOR) :-

Since TEGs are solid-state devices, they don't have any moving parts while they're operating[5]. They are the most popular waste heat recovery devices due to their noiseless operation and lack of hazardous materials. The large amount of waste heat released during I.C. engine running makes it possible to generate useful energy[6].

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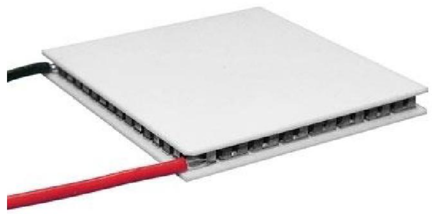

Fig 2.1: Teg

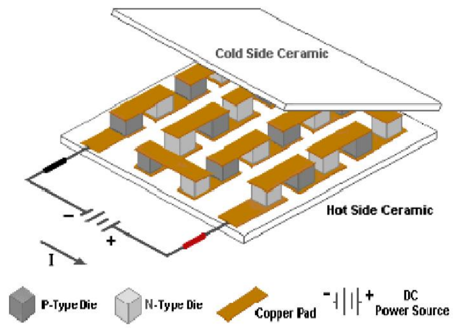

Fig 2.2: Internal Structure of Teg

POWER GENERATION IN PELTIER PLATE BY SEEBECK EFFECT:

Seebeck discovered that electrical current would flow through the connections of two dissimilar conductors if a temperature gradient were applied across them. The effect is displayed in the figure below.

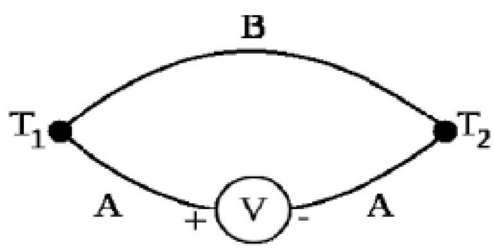

Fig 2.3: Seeback Effect

Power density and temperature range are the two most important variables for waste heat quality.

The majority[8] of industry research pertaining to waste heat recovery focuses on the EGP. A significant amount of industrial waste heat is contained in the exhaust system. In exhaust gas pipes, the gas flow is comparatively steady[7]. Figure illustrates how TEG uses the heat from exhaust gas to function. The temperature differential between the coolant on the cold side and the exhaust gas on the hot side is nearly 373 K when the exhaust temperature is 973 K or higher. Ten watts of power can be produced by this temperature differential[9].

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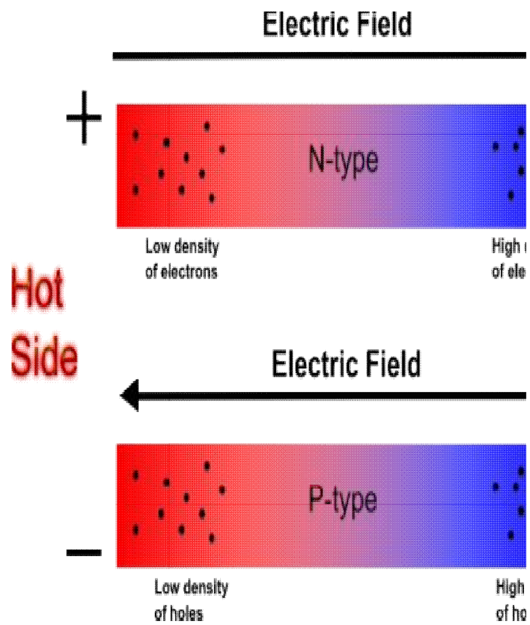
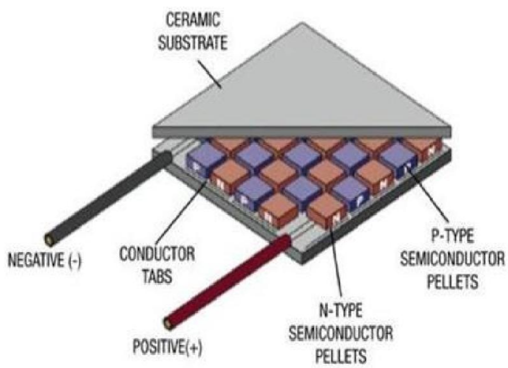
CAD MODEL





OVERALL SYSTEM

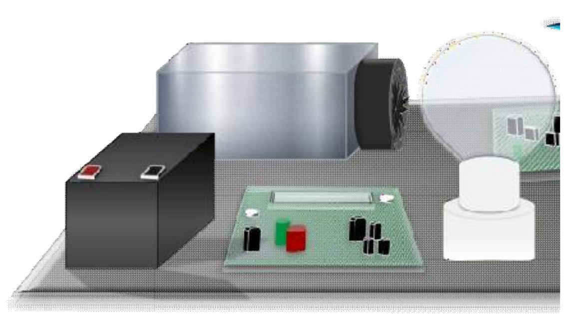


Fig 2.4: Overall Setup

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BENEFITS

- Since TEGs are solid-state devices, they don't have any moving parts while they're operating. Because there are no moving parts, less maintenance is needed, and there are no chlorofluorocarbons. It has a flexible shape, is incredibly tiny, and can maintain temperature control to within fractions of a degree[10].
- Compared to traditional refrigeration, TEGs can be used in settings that are more harsh or smaller. By adjusting the input voltage or current, TEG may be controlled and has a long lifespan.

III. RESULT & CONCLUSION

The advantages of "waste heat recovery" can be roughly divided into two groups.

Direct Benefits:

- The efficiency of the combustion process is directly impacted by waste heat recovery. The decrease in process costs and utility consumption reflects this.

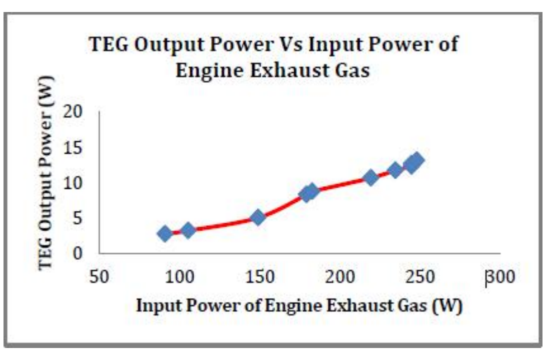
Indirect Benefits:

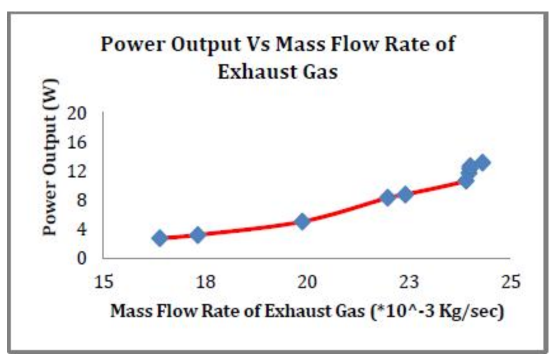
- Pollution reduction: The release of many harmful flammable wastes into the atmosphere, including particulate matter (PM), nitrogen oxides (NOx), hydrocarbons (HC), and carbon monoxide (CO). The amount of pollution in the environment is decreased by heat recovery.
- Equipment size reduction: Waste heat recovery lowers fuel consumption, which lowers the amount of flue gas generated. As a result, equipment sizes are reduced.
- Decrease in auxiliary energy consumption: Another advantage of having smaller equipment is that it uses less auxiliary energy.

The experimental results obtained are tabulated as follows:

Table 1: Voltage generated and boosted for different temperatures

TEMPERATURE DIFFERENCE (K)	VOLTAGE WITHOUT BOOSTING (VOLT)	VOLTAGE AFTER BOOSTING (VOLT)
79	0.02295	1.43
99	0.0269	2.52
119	0.03443	3.20
139	0.04017	3.84
149	0.04017	3.84
159	0.04591	4.93
179	0.05165	5.36
199	0.05739	6.09





TEG Output Power Vs Input Power of Exhaust heat Gas Power Output Vs Mass Flow Rate of Exhaust Heat Gas

The power output is a function of the exhaust gas mass flow rate, as the graph illustrates. The TEG system generates an average of 10.1 W of electricity at an exhaust gas mass flow rate of 24.327 kg/sec.

The process of recovering and reusing internal combustion engine waste heat for heating or producing mechanical or electrical work is known as waste heat recovery. If the automakers embraced these technology, it would also be easier to see how the engine's performance and emissions improved.

IV. CONCLUSION

The process of recovering and recycling industrial machinery's waste heat to produce electricity is known as waste heat recovery. If the industrial industries embraced these technology, it would also be easier to see how the machines' performance and emissions improved.A significant amount of electricity can be produced if the thermoelectric system concept is implemented in practice, and this electricity will be used to power industrial loads. This technology also continuously consumes a significant quantity of heat waste for pollution. Additionally, these industries contribute in some way to preventing environmental contamination.

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