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# Analysis of Power Generation using Waste Heat in Industries usingThermoelectric Generator

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***Keywords*— Waste heat from I. C. Engine, waste heat Recovery, TEGs, Electricity.**

***Abstract*—** *Recently, increased emphasis has been placed on the global issue of rapid economic growth, a relative energy scarcity, internal combustion engine exhaust waste heat, and environmental degradation. About 30 to 40 percent of the total heat delivered to theengine in the form of fuel is transformed into meaningful mechanical work. It is necessary to convert waste heat into usable work since the leftover heat is released into the environment through exhaust gases and engine cooling systems, leading to an increase in entropy and major environmental degradation. Due to the specific advantages of thermoelectric generators, they have emerged as a possible alternative green technology as waste heat recovering techniques like the thermoelectric generator (TEG) are developed. A techniquethat can directly convert the thermal energy found in exhaust gas into electric power is the subject of the majority of current study. In this research, a thermoelectric power generator based on exhaust gas was developed for industrial use. The exhaust gases in the pipe serve as the thermoelectric power generator's heat source. As a result, this study suggests and puts into practice a thermoelectric waste heat energy recovery system using the exhaust heat from running equipment.*

*The goal of the project is to directly transform the heat energy from vehicle waste heat to electrical energy using a thermoelectric generator. Although the largest amount of electric power produced by such a system is just 10 W from a single TEG module, significant advancements in material science can make the ambitious aim of generating larger wattages by any means a real possibility.*

## I. INTRODUCTION

The Internal Combustion Engine has been a primary power source for automobiles and automotive over the past century. Presently, high fuel costs andconcerns about foreign oil dependence have resulted in increasingly complex engine designs to decrease fuel consumption.

In this project we are generating electrical power as non-conventional method by heat energy Nonconventional energy systems very essential at this time to our nation. Non-conventional energy using is converting mechanical energy

into the electrical energy.

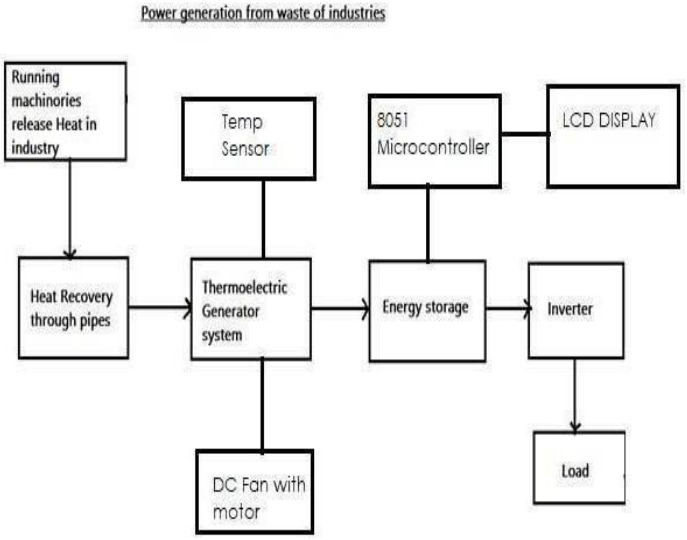
Here in this project a mechanical arrangement is made. Use of embedded technology makes this systemefficient and reliable. Micro controller allows dynamic and faster control. Liquid crystal display (LCD) makes the system user-friendly. Arduino controller is the heart of the circuit as it controls all the functions.

In this project the conversion of the Heat energy in to electrical energy. By using this energy fan will operate and the energy is stored in a battery. The control mechanism carries the A.C ripples neutralizer, unidirectional current controller and 12V, from this battery supply will pass to the inverter and it is used to drive AC/DC loads. The battery is connected to the inverter. This inverter is used to convert the 12 Volt D.Cto the 230 Volt A.C. This 230 Volt A.C voltage is used toactivate the loads. We are using conventional battery charging unit also for giving supply to the circuitry. In this project we are using TEP Transducer. Transducer is a device which converts one form of energy in to another form of energy. This includes electrical, mechanical, light and heat energy also. While the term transducer commonly implies the use of sensors/detector any device which converts energy considered as Transducer.

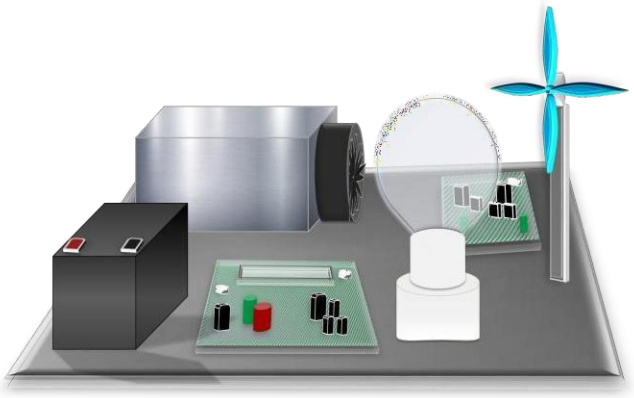
## II. OBJECTIVE

- To study the available literature and research on Industrial waste heat and its solutions.
- To study TEG application and its performance.
- To find out the suitable working of Heat to electricity through TEG Module and collect the literature on the studies.
- To develop the experimental setup for the investigation
- The current research is focusing on a technology, which is able to convert the thermal energy contained in the exhaust gas directly into electric power. In this project concept it invented exhaust gas-based thermoelectric power generator for an industry application.
- In this invention, the exhaust gas gases in the pipe provide the heat source to the thermoelectric power generator. So, this project proposes and implements a thermoelectric waste heat energy recovery system fromthe exhaust heat from running machineries.
- The key is to directly convert the heat energy from automotive waste heat to electrical energy using a thermoelectric generator. While the electric power generation by such a system is able to generate is still relatively small at a maximum of 10 W from a single TEG module, rapid progress in materials research can make the ambitious objective of generating higher watts by all means of feasible proposition.

## III. EXPERIMENTAL BLOCK DIAGRAM




## IV. CAD DIAGRAM

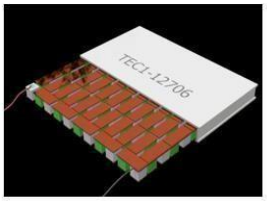


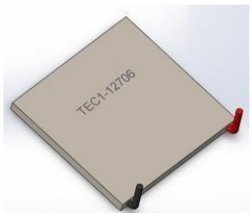
## V. COMPONENTS SPECIFICATION

- 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)

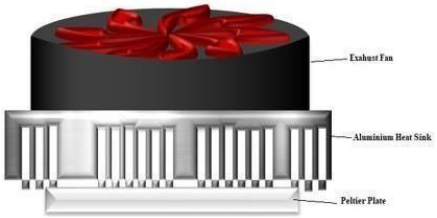
- LCD display (16*2)
- wiring
- switches
- LED bulb
- Metallic Frame
- connector circuit board
- Adapter

THERMOELECTRIC PLATE

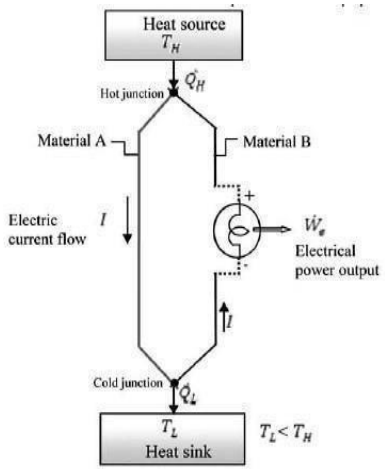



THERMOELECTRIC GENERATOR




## VI. WORKING PRINCIPLE




TEG consists of one hot side and one cold side. The hot side with higher temperature, will drive electrons in the n-type leg toward the cold side with lower temperature, which cross the metallic interconnect, and pass into the p- type leg, thus developing a current through the circuit.

If temperature difference is kept constant, then the diffusion of charge carriers will form a constant heat current, hence a constant electrical current.

## VII. WORKING

- Non-conventional energy using is converting mechanical energy into the electrical energy. Here in this project a power generation arrangement is made. Use of thermoelectric principle makes this system efficient and reliable.
- In any industry machineries continuously run for their production. It release large amount of heat. This is wastage heat. We utilized this wastage heat to produceelectricity. In this way we can minimize some amount air pollution also.
- When we apply TEG with Heat sink module to wastage heat through heat pipe executed from machine. Then at the same time TEG starts converting Heat energy into Electrical energy. We can measure this heat with the help of temperature sensor attached to the system.
- One DC fan is attached to system to indicates the flow and conversion of heat energy into Electrical energy. As the amount of temperature is increases, the flow of fan is also increases.
- Generated electrical energy is stored in battery. This stored energy is supply to inverter to convert DC to AC.
- At the output AC load is obtain. This AC load is utilized to run various loads in same industry like, fan, AC , light etc.
- We also attached 8051 microcontroller (AT89S52) with LCD display to measure the amount of voltage stored and remaining in battery.
- In this way, whole system work. Start from wastage of heat dissipated in industry through production process. Then conversion of heat into electricity. Indication of conversion electricity through DC fan and motor. Storage of electricity in battery. Conversion of DC voltage to AC voltage with help of inverter. Microcontroller attached to show the voltage present at battery. And last AC load attached to inverter.
- If such system utilized in automobiles industry, the

amount of wastage heat we can utilized it. And also minimized air pollution problem cussing by vehicles.

## VIII. RESULTS & DISCUSSION

- Benefits of 'waste heat recovery' can be broadlyclassified in two categories
- Direct Benefits:
- Recovery of waste heat has a direct effect on the combustion process efficiency. This is reflected by reduction in the utility consumption and process cost.
- Indirect Benefits:
- Reduction in pollution: A number of toxic combustible wastes such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx),and particulate matter (PM) etc, releasing to atmosphere. Recovering of heat reduces the environmental pollution levels.
- b) Reduction in equipment sizes: Waste heat recovery reduces the fuel consumption, which leads to reduction in the flue gas produced. This results in reduction in equipment sizes.
- c) Reduction in auxiliary energy consumption: Reduction in equipment sizes gives additionalbenefits in the form of reduction in auxiliary energy consumption.

Design Calculations for Petrol Engine:

*Table Specification of Petrol Engine*

| | |
|---|---|
| Type | Two Stroke |
| Cooling System | Air Cooled |
| Bore /Stroke | 50 * 50 mm |
| Compression Ratio | 98.2 cc |
| Piston Displacement | 6.6 ;1 |
| Maximum Torque | 0.98 kg-m at 5500 RPM |

Calculation for Voltage generated From the equation of Seeback effect,V=α (Th - Tc)

Where, V – Voltage Generated in Voltsα – Seebeck coefficient in μV/K

Th-temperature of hot surface (silencer) in Kelvin

Tc-temperature of cold surface (atmosphere) in Kelvinα of Bismuth Telluride - 287μV/K

Tc = 303 k

A few temperatures of the hot silencer is taken into consideration and the corresponding

voltages that are expected to be generated according to the Seebeck equation is calculated as

follows,

V = α (Th - Tc)

Case 1: Th= 403 k V= (287 *10-6)* (403-303) = (287 *10-6)*(100) = 0.0287 V

Case 2: Th= 453 k V = (287 *10-6)* (453-303) = (287 *10-6)*(150) = 0.04305 V These

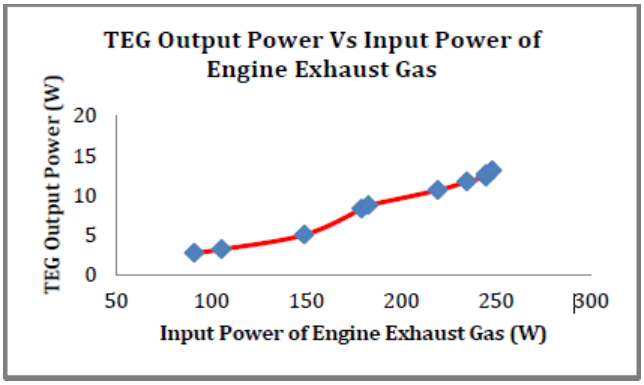
voltages are meager in value. This can be boosted up usingthe booster circuit.

Total Power

T1= Hot side inlet temperature T2= Hot side outlet temperature T3= Cold side inlet temperature T4= Cold side outlet temperature

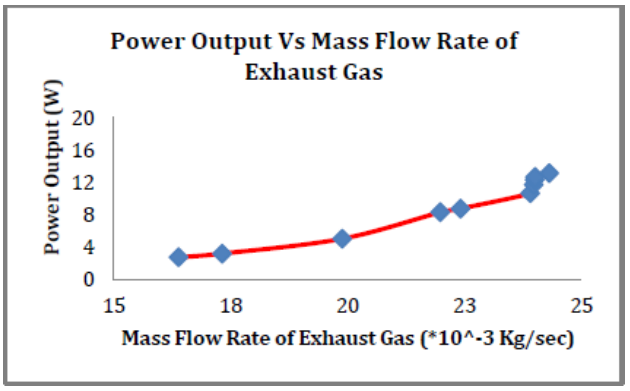
Tin= Exhaust gas temperature at TEG system inletTex= Exhaust gas temperature at TEG system exit

**TEG Output Power Vs Input Power of Exhaustheat Gas**




The graph shows that at the engine speed of 3736 rpm, input power of engine exhaust gas is 248.03 W & the TEG output power is 10 W, hence the overall efficiency obtained is 5.28%.

**Power Output Vs Mass Flow Rate of Exhaust Heat Gas**




The graph shows that the power output is function of mass flowrate of exhaust gas. At the mass flow rate of exhaust gas of

24.317 Kg/sec. the power developed by TEG system is average 10 W.

Waste heat recovery entails capturing and reusing the waste heatfrom internal combustion engine and using it for heating or generating mechanical or electrical work. It would also help to recognize the improvement in performance and emissions of the engine if these technologies were adopted by the automotive manufacturers.

By using this thermoelectric system one can generate electricity from the high temperature difference and it is available at low cost. In heavy duty vehicles the smoke coming out of the exhaustion system will form the NOx gases which are major concern for the greenhouse gases. But because of this the temperature will come down of exhaust gases so, the formationof the NOx gases will be minimal.

If this concept of thermoelectric system is taken to the nano level or micro level, then there will be ample amount of electricity can be generated which are just wasted into the atmosphere.

## IX. BENEFITS

- TEGs are solid-state device, which means that they have no moving parts during their operations. No moving parts so maintenance required is less frequently, no chlorofluorocarbons. Temperature control to within fractions of a degree can be maintained, flexible shape, very small size.
- TEGs can be used in environments that are smaller or more severe than conventional refrigeration. TEG has long life, and also it can be controllable by changing the input voltage/current.

## X. ADVANTAGES

- Clean, Noise less, Cost is less .
- This is a Non-conventional system, No fuel is require
- Easy maintenance, portable, charging time is less (maximum temp)
- Promising technology for solving power crisis to an affordable extent.
- Simple in construction, Pollution free, Reduces transmission losses.
- Wide areas of application# Required less space
- It can be use at any time when it necessary.
- Less number of parts required.
- we can charge any electronic devices
- Electricity can used for many purposes
- Efficient and eliminate the grid searching.

## XI. APPLICATIONS

- Thermoelectric Generators are basically used in where the power production is less.
- In many industries amount of heat is executed and been wastage. We can used this hear for electricityusing TEG.
- In automobile vehicle produce heat that can be usedfor generating electricity by using TEG.
- Recharge the battery where ever waste heat isobtained.
- Self charging battery by fixing the TEG at radiatoror two wheeler silencers pipe.

## XII. CONCLUSION

Waste heat recovery entails capturing and reusing the waste heat from machineries in industries and using it for generating electrical work. It would also help to recognize the improvement in performance and emissions of the machineries if these technologies were adopted by the production industries.

If this concept of thermoelectric system is taken to the practical level then there will be large amount of electricity can be generated, which will be used to run industrial load itself. Also large amount of wastage heat for pollution is also usesin this system in continue manner. And such industries also somehow help to protect the environmental pollution.

## SCOPE OF THE STUDY

- By using thermoelectric generator connecting in series/ parallel we can generate the power for maximum level
- Even body heat also generate the heat that can be utilizing by using TEG to generate the power to
- charge the portable equipment like laptop mobile etc
- By installed in the vehicle above the radiator means thevehicle battery will charge self.

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