© 2020 IJSRST | Volume 5 | Issue 7 | Print ISSN : 2395-6011 | Online ISSN: 2395-602X

4th National Conference on Advances in Engineering and Applied Science
Organized by : Anjuman College of Engineering and Technology (ACET) Nagpur, Maharashtra, India, In association with
International Journal of Scientific Research in Science and Technology

Design of Prototype of Power Generation from Waste heat of Industries using Thermoelectric Generator

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ABSTRACT

This paper presents the investigation of power generation using the combination of heat and thermo-electric generators. A majority of thermal energy in the industry is dissipated as waste heat to the environment. This waste heat can be utilized further for power generation. The related problems of global warming and dwindling fossil fuel supplies has led to improving the efficiency of any industrial process being a priority. One method to improve the efficiency is to develop methods to utilize waste heat that is usually wasted. Two promising technologies that were found to be useful for this purpose were thermoelectric generators and heat pipes. Therefore, this project involved making a bench type, proof of concept model of power production by thermoelectric generators using heat pipes and simulated hot air. In recent years, global warming and the limitations in use of energy resources increase environmental issues of emissions. Also In industry, most of the expenses are due to energy (both electrical and thermal), labour and materials. Yet, out of them vitality would identify with the sensibility of the expense or potential cost investment funds and therefore vitality the board will help in cost decrease. The possibilities of thermoelectric systems' contribution to "green" technologies, specifically for waste heat recovery from industry exhausting flue gases. It results into extensive research on green technologies producing electricity. As waste heat recovering techniques, such as thermoelectric generator (TEG) is developed. Its implementation in automobile industry is carried out in many ways.

Keywords : Waste Heat From , Waste Heat Recovery, Thermoelectric Generator Module, Controller, Electricity.

I. INTRODUCTION

In recent years, an increasing concern of environmental issues of emissions, in particular global warming and the limitations of energy resources has resulted in extensive research into novel technologies of generating electrical power. Thermoelectric power generators have emerged as a promising alternative green technology due to their distinct advantages.

Previous research shows that TEG as a waste heat harvesting method is useful. Due to distinct benefits of Thermoelectric generators, they have become a promising alternative green technology. Thermoelectric generator direct converts waste-heat energy into electrical power where it is unnecessary to consider the cost of the thermal energy input. The application of this technology can also improve the overall efficiency the of energy conversion systems.

A thermoelectric power generator is a solid state device that provides direct energy conversion from thermal energy (heat) due to a temperature gradient into electrical energy based on "Seebeck effect".

The thermoelectric power cycle, with charge carriers (electrons) serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine. Thermoelectric power generators offer several distinct advantages over other technologies.

They are extremely reliable (typically exceed 100,000 hours of steady-state operation) and silent in operation Since they have no mechanical moving parts and require considerably less maintenance;

- They are simple, compact and safe;
- They have very small size and virtually weightless;
- They are capable of operating at elevated temperatures;
- They are suited for small-scale and remote applications
- Typical of rural power supply, where there is limited or no electricity;
- They are environmentally friendly;
- They are not position-dependent; and
- They are flexible power sources.

In this project the conversion of the Heat energy in to electrical energy. By using this energy fan will operates 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.C to the 230 Volt A.C. This 230 Volt A.C voltage is used to activate the loads. We are using 8051 microcontroller AT 89S52 with 16*2 LCD display the voltage from the values of battery.

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.

The following literature papers studies for the completion of prototype. Most of the recent research activities on applications of t Literature survey 2:- Mariem SAIDA, Ghada ZAIBI, Mounir SAMET, Abdennaceur KACHOURI, A new design of thermoelectric generator for health monitoring, 2017 International Conference on Smart, Monitored and Controlled Cities (SM2C), Kerkennah, Tunisia, February, 17-19, 2017, p 59-63 , From literature survey 2 we analysed about thermoelectric generator and its specification.

Literature survey 3:- Ahaad Hussein Alladeen, Shanshui Yang, Yazhu Liu, Feng Cao, Thermoelectric waste heat recovery with cooling system for low gradient temperature using power conditioning to supply 28V to a DC bus, 2017 IEEE Transportation Electrification Conference and Expo, Asia-Pacific (ITEC Asia-Pacific), 2017 , From literature survey 3 we studied different types of cooling system and different types of coolant.

Literature survey 4:- Arash Edvin Risseh, Electrical Power Conditioning System for Thermoelectric Waste Heat Recovery in Commercial Vehicles, IEEE Transactions on transportation electrification, 2018, p 2-16 , From literature survey 4 we got an idea about how to recover the waste heat from automobile application

hermoelectric power generation have been directed towards utilisation of industrial waste heat. Vast amounts of heat are rejected from industry, manufacturing plants and power utilities as gases or liquids at temperature which are too low to be used in conventional generating units (<450 K).

In this large-scale application, thermoelectric power generators offer a potential alternative of electricity generation powered by waste heat energy that would contribute to solving the worldwide energy crisis, and the same time help reduce environmental global warming. In particular, the replacement of by-heat boiler and gas turbine by thermoelectric power generators makes it capable of largely reducing capital cost, increasing stability, saving energy source, and protecting environment. recover waste heat and how to utilize waste heat from different industries Literature survey 5:- T.J Zhu, Y.Q. Cao, F. Yan And X.B. Zhao, nano structuring and Thermoelectric properties of Semiconductor Tellurides, 2007 International Conference on Thermo electrics. From literature survey 5 we knew about thermoelectric materials and its properties.

II. OBJECTIVES

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 from the 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.

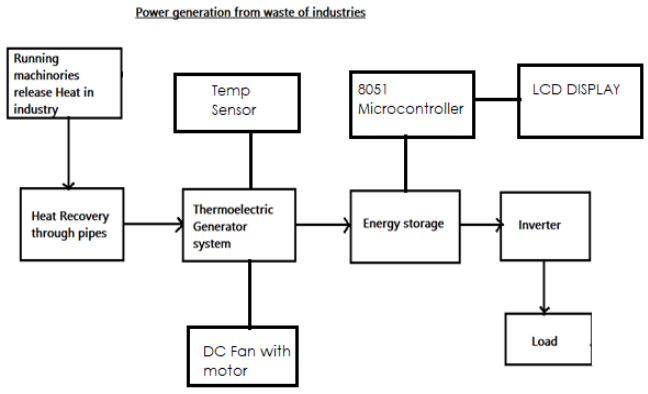
Availability of Waste Heat from machine

The quantity of waste heat contained in a exhaust gas is a function of both the temperature and the mass flow rate of the exhaust gas:

$$\dot{Q} = \dot{m} \times C_p \times \Delta T$$

Where, $\dot{Q}$ is the heat loss (kJ/min); $\dot{m}$ is the exhaust gas mass flow rate (kg/min); C_p is the specific heat of exhaust gas (kJ/kg°K); and ΔT is temperature gradient in °K. In order to enable heat transfer and recovery, it is necessary that the waste heat source temperature is higher than the heat sink temperature. Moreover, the magnitude of the temperature difference between the heat source and sink is an important determinant of waste heat's utility or "quality". The source and sink temperature difference influences the rate at which heat is transferred per unit surface area of recovery system, and the maximum theoretical efficiency of converting thermal from the heat source to another form of energy (i.e., mechanical or electrical). Finally, the temperature range has important function for the selection of waste heat recovery system designs.

Block diagram



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 produce electricity. 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.

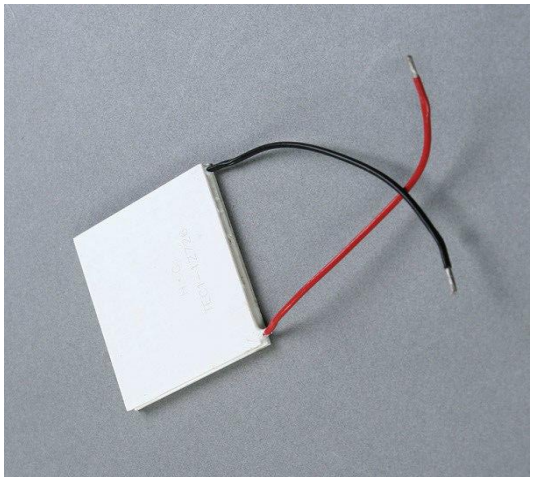
In this way, whole system work. Start from wastage of heat dissipated in industry through production process. Then conversion of heat into electricity. Indication of conversion electricity through DC fan and motor. Storage of electricity in battery. Conversion of DC voltage to AC voltage with help of inverter. Microcontroller attached to show the voltage present at battery. And last AC load attached to inverter.

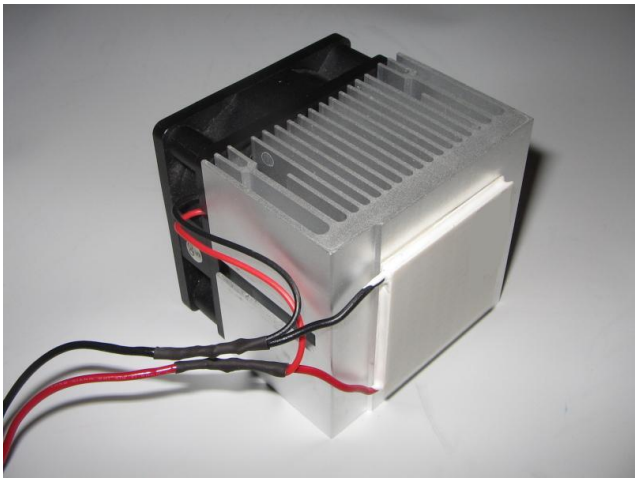
If such system utilized in industry, the amount of wastage heat we can utilized it. And also minimized air pollution problem cussing in industry.

Thermoelectric plate

The Thermoelectric plate (TEP transducer) is known as the peltier plate .the TEP extends to THERMO ELECTRIC PLATE.

The Peltier Plate is a smart swap temperature control option providing a temperature range of –40 to 180 °C, with a maximum heating rate of 30 °C/min, and temperature accuracy of +/- 0.1 °C. A platinum resistance thermometer (PRT) sensor is positioned in the middle of the lower sample plate and ensures accurate measurement and control of sample temperature. It is the most common system for standard parallel plate and cone and plate testing of structured fluids. The open design facilitates easy sample loading and cleaning of geometries.





- **Thermoelectric effect**:

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side.

This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers.

Seebeck Effect

Seebeck found that if you placed a temperature gradient across the junctions of two dissimilar conductors, electrical current would flow. The effect is shown below in the Fig.

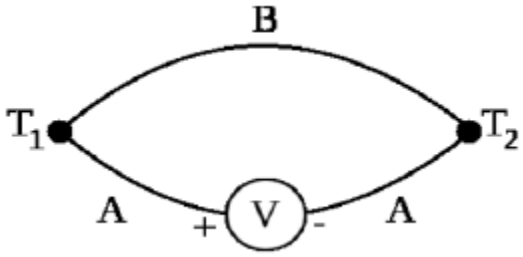


Fig. Seeback effect

- **TEG 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 as sown in Fig.4.1. Holes in the p-type leg will then follow in the direction of the current. The current can then be used to power a load.

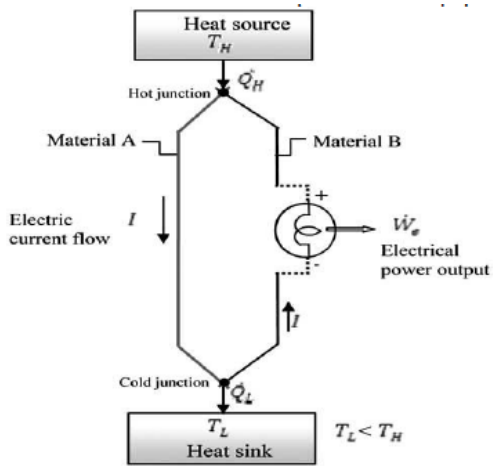


Fig. Principle of thermoelectric generator

If temperature difference is kept constant, then the diffusion of charge carriers will form a constant heat current, hence a constant electrical current. If the rate of diffusion carriers were equal, there would be no net change in charge within the TE leg.

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 inlet
Tex= Exhaust gas temperature at TEG system exit

III. RESULT

TEG Output Power Vs Input Power of Exhaust heat Gas

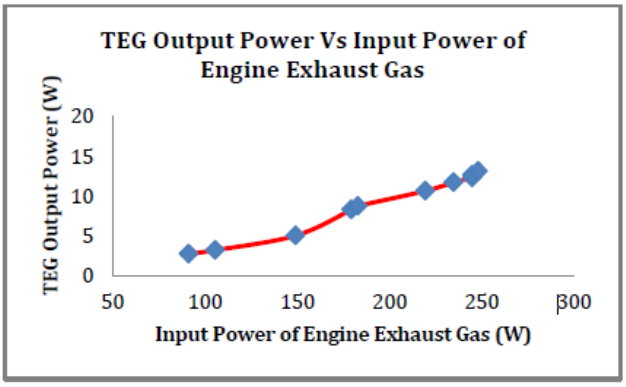


Fig. TEG Output Power Vs Input Power

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 13.106 W, hence the overall efficiency obtained is 5.28%.

Power Output Vs Mass Flow Rate of Exhaust Heat Gas

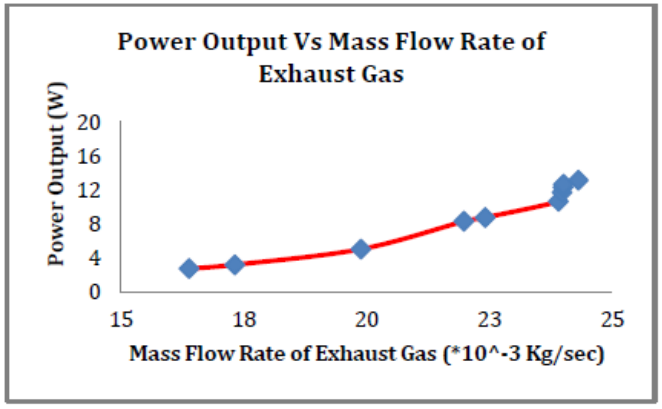
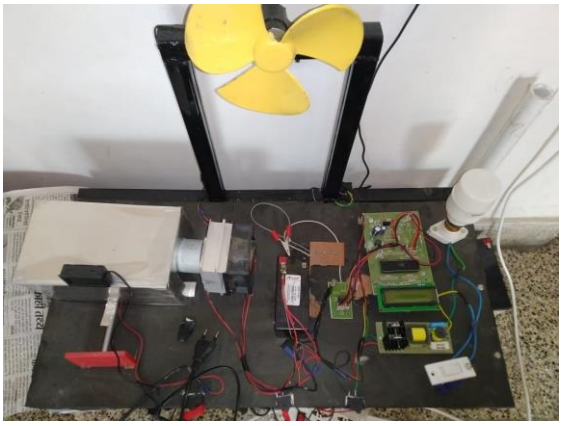


Fig. Power Output Vs Mass Flow Rate of Exhaust heat Gas

The graph shows that the power output is function of mass flow rate 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.

Experimental Project Image



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 the vehicle battery will charge self.

IV. 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 uses in this system in continue manner. And such industries also somehow help to protect the environmental pollution.

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