POWER GENERATION FROM LOW GRADE WASTE HEAT USING THERMOELECTRIC GENERATOR

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Abstract - In the conventional method for generate electricity is converting thermal energy into mechanical energy then to electrical energy. In recent years, due to environmental issues like emissions, global warming, etc., are the limiting factor for the energy resources which resulting in extensive research and novel technologies are required to generate electric power. Thermoelectric power generators have emerged as a promising another green technology due to their diverse advantages. Thermo Electric Power Generator directly converts this Thermal energy into Electrical energy. So number of moving and rotating part has been eliminated. By this it eliminated emission so we can believe this green technology. Thermoelectric power generation offer a potential application in the direct exchange of waste-heat energy into electrical power where it is unnecessary to believe the cost of the thermal energy input. The application of this option green technology in converting waste-heat energy directly into electrical power can too improve the overall efficiencies of energy conversion systems. Heat source which is need for this conversion is less when contrast to conventional methods. In this paper, a background on the basic concepts of thermoelectric power generation is presented and recent patents of thermoelectric power generation with their important and relevant applications to waste-heat energy are reviewed and discussed.

Keywords: - Thermoelectric power generator, waste-heat recovery, alternative green technology, direct energy conversion, thermocouple

I. INTRODUCTION

A Thermoelectric power generator is a solid state device that provides direct energy conversion from thermal energy (heat) into electrical energy based on "Seebeck effect". The thermoelectric power cycle, with charge carriers serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine. Advantages of Thermoelectric power generators over other technologies.

- They are extremely reliable and they have no mechanical moving parts and require considerably less maintenance.
- They have very small size and weightless.
- They have the capacity to operating at elevated temperatures.
- The source for the power generation is Heat not Light, so day and night operation is possible.
- They are mostly used for convert the waste heat so it is considered as a Green Technology.
- We can increase the overall efficiency of the system (4% to &7%).
- They can be alternative power sources.
- When compare to exciting conventional power system it require less space and cost
- Less operating cost.

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. This contribution analyzes approaches that led to discovery of thermo electricity. Thermoelectric restrictions imposed on the application areas of thermoelectric generators and, accordingly, theensuing rational lines of their practical applications are considered. The possibilities of thermoelectric systems' contribution to "green" technologies, in particular, to waste heat recovery from industry exhausting flue gases. Attention is focused on the selection of the thermoelectric system and the experimental model representing the system. Finally there is theoretical model calculation for generation of emfs (voltage) and validation comparing the experimental results of the emfs (voltage). The Drawback of thermoelectric power generator is their relatively low conversion efficiency (typically ~5%) and Less power output. Application over the past decade included industrial instruments, military, medical and aerospace and home reason and applications for portable or remote power generation. Though, in recent years, an increasing anxiety of environmental issues of emissions, in particular global warming has resulted in extensive research into nonconventional technologies of generating electrical power. Thermoelectric power generation offers a promising technology in the direct conversion of low-grade thermal energy, such as waste-heat energy, into electrical power.

Perhaps the earliest application is the use of waste heat from a kerosene lamp to provide thermoelectric power to power a wireless set. Thermoelectric generators have also been used to provide small amounts electrical power to remote regions for example Northern Sweden, as an alternative to costly gasoline powered motor generators. Oldest technology behind this technology is seebeck effect on Thermocouple now this tech using in seebeck effect on semiconductors so it can eliminate wires, so wireless technology is possible. An important purpose in thermoelectric power generation using waste heat energy is to decrease the cost-per-watt of the devices. Moreover, cost-per-watt can be reduced by optimizing the device geometry, improving the manufacture quality and simply by operating the device at a larger temperature difference. Analyze the thermoelectric property of the module material is very important. Good thermoelectric material has seebeck property in between 200-300μV/K. Material thermoelectric material figure-of-merit property should be near or more than 3×10-3 for good material. This TEG is used to convert the waste heat emitted from Jet Engine, IC Engines, Furnace, Heat water conveyor tubes.

II. LITERATURE SURVEY

Method for generating power such as burning of wood, petrol, diesel, coal, is continuously depleting with nature, so that exceeded usage of electricity according to the consumer demand. Global warming is the increase in the average measured temperature of the Earth's near surface air and Oceans since the mid-20th century, and its projected continuation. Global surface temperature increased 0.74 ± 0.18 °C (1.33 ± 0.32 °F) during the **Thomas Jon Seebeck (1934)** invented that a temperature formed between two dissimilar conductors produces a voltage and current. At the heart of the thermoelectric generator effect is the fact that a temperature difference in a conducting material results in heat flow between one side to another side

Table 1: Summary from related literature

Author(s) & year	Type of work	Hot side & cold side temperature	TEG module number	Achievements
Rowe et al (1997)[7]	Exp	Hot water=90°C, Cold water=14°C	36	Max. power =95W
Crane et al (2004)[8]	Exp	Hot water=90°C, Cold air=25°C	6	Max. power=0.54 W
Niu et al (2009)[9]	Exp	Hot fluid=90°C, Cold fluid=25°C	56	Max power =146.5W
Gou et al (2010)[10]	Exp	Hot water=80°C, Cold air=24°C	10	Max. power =0.85W
Kim et al (2011) [11]	Exp	Hot water =95°C, Cold air=45°C	72	Max. power = 75W
Gou et al (2013)[12]	Exp	Hot water=90°C, Cold air=28.5°C	18	Max. power =6.5W
B. Orr et al (2016)[13]	Exp	Hot exhaust air =218°C, Cold air=31°C	8	Max. power =38W
Remeli et al (2016)[4]	Exp	Hot air =160°C, Cold air=65°C	1	Max. power =1.72W

All these studies were experimental and some of them were able to generate significant amount of electrical power. So, above literature only concentrated on testing commercially available TEG performances; none of current literature make known to an optimization technique to maximize the net electrical power by considering losses due to thermal resistance and parasitic power losses. In this works, a system has considered which consisted thermoelectric modules sandwiched between hot water and cold-water channel. TEG can produced electricity from the temperature difference between hot and cold water. This power generation is increased with the higher temperature difference and higher mass flow rate, but there is a penalty for higher mass flow rate called parasitic loss. This parasitic loss also depends on the size of the heat exchanger. So, the amount of net power/ useful power from this system depends on size of channel, mass flow rate, efficiency of TEG modules, number of modules and parasitic power. For chosen TEG modules, efficiency is fixed and number of TEG has considered also fixed for this study. So, maximum net power depends on proper selection of length, width and gap height of water channel and depends on suitable selection of mass flow rate. The novelty of this study is proposed mathematical model to predict gross power, parasitic power and net power where mass flow rate, gap height, length and width have taken as variables. Number of TEG and its property(such as dimensions, efficiency and thermal resistance)have considered as fixed. As the number of TEG and its dimensions fixed, channel length and width are interrelated [6]. Proposed model will help to predict maximum net power, optimized channel dimensions ands uitable flow rate for defined conditions. Predicted results from proposed model will be validated by experiments. This model will be useful for system optimisation.

III. PROBLEM DEFINITION

Some developing countries and most populated industrialized countries (India china Mongolia Korea)etc. have average of 3 to 10 hours of daily power-cuts because the increase in demand of consumer utilization electricity exceeds so that the

production of electrical energy is lesser then the consumer dem and. And also shortage of fossil fuel and coal i.e. about 60% of electricity is generated from fossil fuels. (Oil and gas) are imported from Arabian countries. So that pollution also may occur due to the combustion of this fossil fuel. And also the generating the power from these conventional sources may lead to harmful environment and pollute the nature.

In the new generation they are depending upon the rechargeable batteries or diesel /petrol engine etc. when there is no power and at the time of load shedding. The use of generator is common in industrial and commercial sector. This ultimately increases the shortage of power and more cost. And also the people are not utilizing the power properly they were unnecessarily wasting the power and they are not designing the power consumption properly hence basically a low power production in that also wasting means in the future we live with outlight Now a days consumer demand is more then the power production that is the major difficulty to overcome.

IV. OBJECTIVE

The main aim of this project is to develop much cleaner noise less cost effective different way of power generation method for charging the battery as well as to utilization proper only the requirement of usage, which helps to reduces the global warming as well as reduce the power shortages, load shedding and also we can transfer the portable generating unit. In this project the conversion of waste heat into generate electricity by using thermoelectric generator. Waste may refrigerator heat, vehicle radiator heat, laptop heat, even body heat can be used as a input source as a waste heat to generate electricity and it can be charged directly mobile battery and also stored in a rechargeable lead acid battery for further usage. And also waste energy human body locomotion also produce electricity body weight locomotion of the energy in to electrical energy by using electromagnetic induction principle. The control mechanism carries regulator circuit etc and the power saving mechanism carries microcontroller relays etc.

1) Charge the mobile battery where ever waste heat is obtained
2) Maintain the heat transfer from hot side to cold side because of uniform charging mobile battery
3) Charge the 12v battery for further usage to converting by using inverter to 220v

V. SCOPE OF THE STUDY

The scopes of project study are;

1) By using thermoelectric generator connecting in series /parallel we can generate the power for maximum level
2) 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
3) By installed in the vehicle above the radiator means the vehicle battery will charge self

VI. BLOCK DIAGRAM

This section gives the brief description of each component used in designing the waste heat to generate electricity By using this thermo electric power generation (TEPG) TEC12706 devices shown When ever heating of one surface (waste heat example refrigerator outer surface heat, laptop heat,ion box heat, solar radiation heat ,even human body heat) is also an input of thermo electric generator. When heat is applied one side there will be a continuous electron or holes will flow continuously based on the temperature of heat. If the temperature is increases the voltage is also increases vice verse in such a way that the other side of thermoelectric generator is cold because heat transform is uniformthen only electron will flow and voltage is developed at the output side of the thermoelectric generator

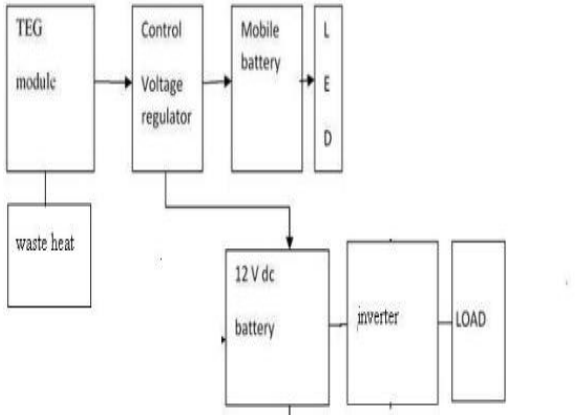

Fig 1: Block Diagram Voltage regulator (control circuit)

In this part voltage from the TEG is regulated by required voltage for mobile charger

Mobile battery

After the regulated voltage is passed to the battery terminal to charge the mobile so that the required specification is 3.8 v li-ion batteries 5.70wh is required. Finally the mobile battery will charge under desired voltage condition

LED (light emitting diode)

Led indicates that mobile battery is charging or not if the led will not glow means there is no power at the output side and also the battery will not get charging. Inverter Used for to convert variable dc to fixed ac Thermoelectric generator construction and working principle:

A thermoelectric generator is a solid state flexible device that consists of a P-type and N-type semiconductor particle arranged in series, shown in Figure When heat is applied to one surface of the thermoelectric generator (hot side), N-type (electrons) semiconductor and the holes in the p-type semiconductor will moves out. This movement of electrons

and holes that forms charge. A thermoelectric generator can be connected in series, which increases the voltage, the current.

VII.TEST ANALYSIS

Testing by using waste heat as a iron box

A) Complete setup to charge the mobile battery by using thermoelectric generator

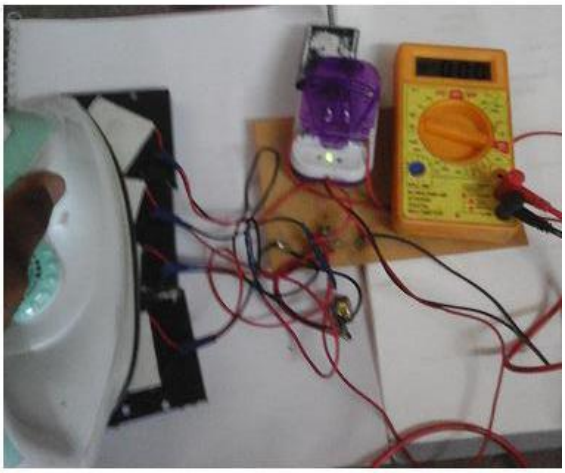

Fig 2: (a) charging the sample mobile battery using TEG by waste heat

complete setup to charge the mobile battery is shown in fig 2, When heat is applied to the hot side the TEG get absorb the heat from any body (exrefrigerator heat, laptop heat, heat from the vehicle, solar heat, and even human body is also a waste heat source for TEG).

Under this when heat absorbs one side it rejected at the other side (cold side) heat transfer take place from hot surface to cold surface. So that the electron will flow to through copper conductor to the complete circuit so voltage will be regulated at the circuit. The required power for the mobile battery is 3.8 volt it is at the output terminal at the circuit is as shown in the fig a

As it is heat transfer take place from heat applied side to cold side. These thermoelectric generators of two terminals are to connected i.e. positive terminal is connected to diode side and the other terminal is connected to ground Circuit elements consist of Diode (BY127),Potentiometer (10kpot),Capacitor (50micro farad),Zener diode(6v),LED (3.5v),Mobile battery (3.8v)

When heat is applied to the hot side under certain temperature (30 to 300 degree C) electrical power from heat flow across a hot to cold side temperature gradient.. more thermoelectric generator need to be connected in cascade to make the maximum voltage. Thermoelectric device diode eliminates the reverse flow of electron to the thermo electric generator so that continuously electron will flow through diode when applied heat to the TEG.

Potentiometer is used to control the voltage.Zener diode helps to eliminate the excess voltage flow to the battery because battery required to charge.

LED (light emitting diode) is shows the battery is charging or not and it ill glow when the output voltage is above 3.5 volt and

b) Test analysis by waste heat from boiler tube

The exhaust of flue gasses sounds very interesting. We believe the efficiency of such a system would be in the range of 10.6% for QW of Si/SiGe. This takes into account 10 C temperature loss on both the hot and cold end of the thermoelectric for heat transfer

We tested five different modules with different semi-conduct materials in order to find the TEG with the maximum output at a specific temperature difference. Fig. 3 shows the schematic of the module tests. The TEG module was clamped tightly in between two containers, one was the hot side with a high temperature and another was the cold side with a low temperature

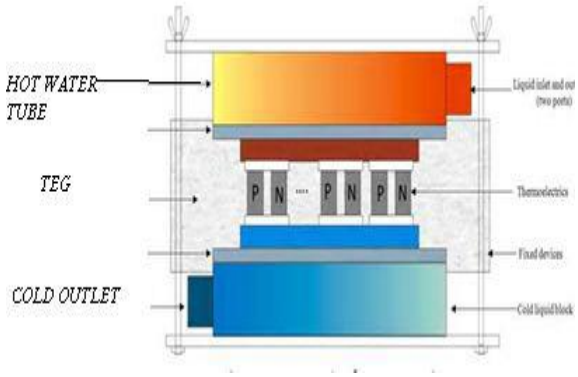

Fig 3: . a) shows the schematic of the module tests.

We kept the temperature on the hot side at about 200°C by using a digital thermostat oil bath and used the tap water as the cooling liquid on the cold side with a temperature of about 20°C. The temperatures of both hot and cold sides were measured and the results are shown in graph. The temperature was measured using two micro-thermocouples with very thin tips.

The temperature on the hot side of the modules was stabilized at about 180°C and that on the cold side at about 40°C. The increase in the temperature on the cold side from 20 to 40°C was because of the heat conduction from the hot side through the TEG modules. The temperature difference was stabilized at around 140°C. The results illustrate that the test system for thermoelectric power generation was stable

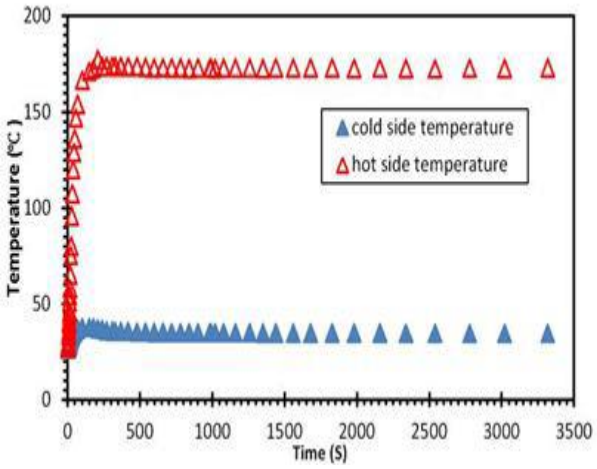

Fig 4: . Temperature

c)Test analysis from burner

Fundamentally, there are four basic components in a te-powered generator: a heat source, a te, a 'cold-side' heat sink, and an electrical load. the system may also include a voltage regulation circuit or a fan for the heat sink. fig.(a)shows one example of such a system.

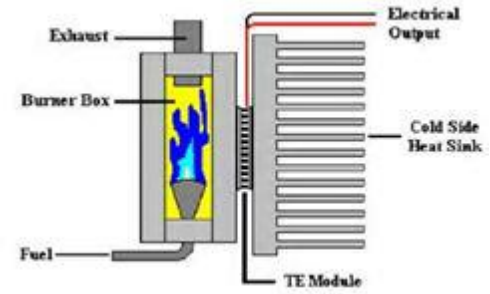

Fig 5.(a)shows one example of such a system.

VIII. RESULT ANALYSIS

Primarily waste heat is used to charge the battery. The system is tested to meet the desired objectives and the results obtained. For the analysis a T.E.G was putted on a hot chamber plate (body heat or iron box I am using here to get fast output and the aluminum heat sink square shaped is placed on the top side (40x40x40) dimension. Heat sink of the other side of the thermoelectric generator (cold side)

The hot plate (iron box) is sated at different temperature ranging from 30℃to220℃. So that to know the voltage and current by using multi meter that was produced by this TEG. by using thermometer to determine the applied temperature exactly on the hot side of the TEG and cold side. The equation is gives to calculate the temperature of the T.E.G.

Equation is given by

Temperature (▲T) = Temperature Hot (Th) – Temperature Cold (tC)

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

DISADVANTAGES

Improper variation of temperature gradient difference may damage the TEG, Complex design

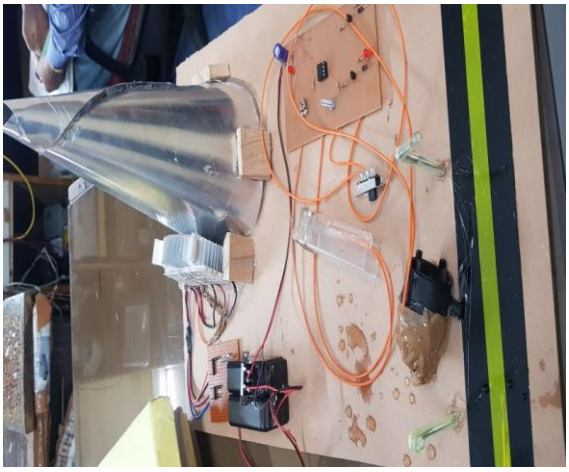

Fig 6: Side view of Chimney of our Project

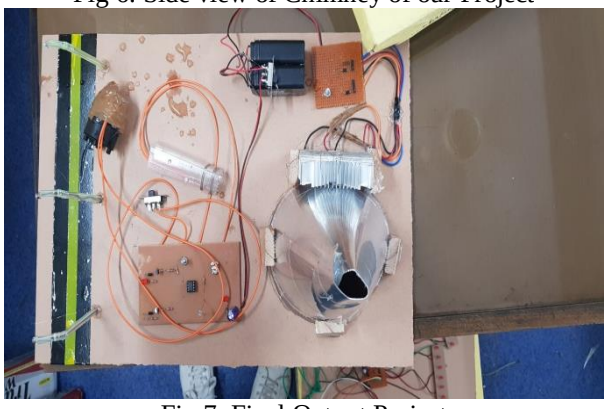

Fig 7: Final Output Project

APPLICATIONS

Thermoelectric Generators are basically used in where the power production is less. In automobile vehicle produce heat that can be used for generating electricity by using TEG. Recharge the battery where ever waste heat is obtained .Self charging battery by fixing the TEG at radiator or two wheeler silencers pipe

IX. CONCLUSION

Present method for electricity generation is converting thermal energy into mechanical energy by turbine then into electricity by using generator. Burning of these fuels causes environmental problem like radio activity pollution, global warming. hence (coal, oil, gas) are the limiting resources resulting new technology is needed. The project paper is tested and implemented. The system gives the best economical pollution free, required energy solution to the people.

Two power generators have been built using TEG modules and tested. The power of the first one could reach about 500 W (predicted using experimental data) with a temperature difference of about 200°C between hot and cold sides. This work can be used for many applications in urban and rural areas where power availability is less or totally absence. By making this system generates and charge 12v which is capable to recharge a mobile. it avoiding dependency of grid supply. This is a Promising technology for solving power crisis to an affordable extent

In this work, five TEG modules have been selected from wide range of commercially available thermoelectric generator. An experiment has been undertaken to select the most suitable thermoelectric module for focused operating conditions. A theoretical model has been proposed to estimate the generated power from thermoelectric based power generation system. This model can calculate the gross power from TEG, parasitic power and net power for all possible combinations and able to predict the optimum net power for specified temperature range and conditions. The optimum operating conditions such as flow rate, heat exchanger dimensions can be found from the proposed model. An experiment has been undertaken to verify the simulated results. Simulated and experimental results are closely matched which can give confident about proposed mathematical model for further use.

SCOPE OF THE FUTURE WORK

- By using proper heat sink material help to increase the output voltage.
- Using long proper heat sink material is to avoid the heat in between the gap of fins.
- By addition of the more TEG in SERIES is to increase the voltage

X. REFERENCE

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