Visvesvaraya Technological University, Belagavi.

PROJECT REPORT

on

SMART POWER GENERATION FROM WASTE HEAT BY THERMO ELECTRIC GENERATOR

Project Report submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Engineering

in

Electronics and Communication Engineering

For the academic year 2019-20

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CERTIFICATE

This is to Certify that the dissertation work **"SMART POWER GENERATION FROM WASTE HEAT BY THERMO ELECTRIC GENERATOR"** carried out by MADHU.N.V USN:1CR16EC070, MAHESH PATIL USN:1CR16EC072, NADENDLA SUJITH USN: 1CR16EC090, NAZIR NADAF USN:1CR16EC095 bonafide students of **CMRIT** in partial fulfillment for the award of **Bachelor of Engineering** in **Electronics and Communication Engineering** of the **Visvesvaraya Technological University, Belagavi,** during the academic year **2019-20**. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said degree.

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ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people who made it possible, whose consistent guidance and encouragement crowned our efforts with success.

We consider it as our privilege to express the gratitude to all those who guided in the completion of the project.

We express my gratitude to Principal, **Dr. Sanjay Jain,** for having provided me the golden opportunity to undertake this project work in their esteemed organization.

We sincerely thank Dr. R. Elumalai, HOD, Department of Electronics and Communication Engineering, CMR Institute of Technology for the immense support given to me.

We express my gratitude to our project guide Preethi A, Assistant Professor,for their support, guidance and suggestions throughout the project work.

Last but not the least, heartful thanks to our parents and friends for their support.

Above all, We thank the Lord Almighty for His grace on us to succeed in this endeavor.

ABSTRACT

Generating electricity in present there is a shortage of fossil fuel, oil, gas, etc. burning of these fuels causes environmental problem like radio activity pollution, global warming etc. So that these (coal, oil, gas) are the limiting resources hence resulting new technology is needed for electricity generation, by using thermoelectric generators to generate power as a most promising technology and environmental free and several advantages in production. Thermoelectric generator can convert directly thermal (heat) energy into electrical energy. In this TEG there are no moving parts and it cannot be producing any waste during power production hence it is considered as a green technology. Thermoelectric power generator converts direct waste heat in to generate electricity 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. This method will have a maximum outcome. 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. By using this energy is used to charge the mobile electronics.

Keywords: Thermoelectric generator, seebeck effect, waste-heat recovery, alternative green technology, direct energy conversion, thermocouple, thermoelectric materials, thermo electric module.

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Chapter 1

INTRODUCTION

In 2017, total world energy consumption was approximately 13,511 million-ton equivalent of petroleum (MTEP). With the fast-industrial growth of developing nations over the last decade, the industrial sector consumed approximately 2852 MTEP. It is estimated that in 2035, the world consumption of energy will increase by more than 30%. Approximately 33% of the total energy consumed in the industry is rejected as residual heat, presenting as a major problem the fact that the most of this rejected energy is identified as low-quality residual heat. This type of waste heat has a small working potential, and the temperatures are below 230°C, which implies a low energy density. Concurrently with the concern for global warming and the issues of diminishing oil consumption, there is a strong incentive for the development of more efficient and clean technologies for heat recovery and energy conversion systems using waste heat.

In order to minimize the waste of energy with residual heat, energy recovery systems have been more explored. These systems can become an important object of research and/or application if, at least, part of the thermal energy expelled by industrial equipment to the atmosphere can be reused. In this context, experimental analysis of the direct conversion of thermal energy into electric energy, using thermoelectric generators, was carried out. The Seebeck effect is related to the appearance of a difference of electric potential between two different materials, placed in contact, however, at different temperatures. Basically, this is the same effect that occurs in thermocouples, where two different materials are connected and submitted to a temperature difference, causing a potential difference to be generated and translated into a temperature reading. In addition to this application, the thermoelectric effect can be explored in the generation of energy for wristwatches and aerospace applications or, even, in the generation of electric energy from the heated gases released in the internal combustion of engines, boiler gases, and/or the geothermal sources.

The thermoelectric generators (TEG) have as main characteristics the reduced dimensions, easy adaptation in complex geometry, and very low maintenance. Its conversion efficiency is about 5%; however, studies conducted at the NASA laboratory have reached 20% efficiency for high temperatures. Recently we are depending upon fossil fuels for maximum electricity generation. However, the reserves of fossil fuels will be going on depleting, since oil & gas are the least sources. Recent years. cost of unit electricity has increasing to unpredictable levels due the less supply of (oil gas coal).

Thus the, green energies are more attractive artificial to electricity generation, as it will also provide a pollution free and cost less. In this innovative project, we are using one device which is used to be created and introduced by human as a renewable energy that is thermo electric generator equipment to generate electricity As we know Renewable energies are, solar energy, wind energy, hydro energy, tidal energy, etc. above energies can produce electricity in different forms and way of generating method.

The device by converting heat energy to electrical energy. This thermoelectric generator is suitable power for space research, Satellites and even unmanned facilities. Satellites are settled at the planets that so for from the earth. For example, thermoelectric devices can be used in vehicles to producing electricity using the waste heat of the engine. TEG is used to convert thermal energy (heat) into electricity based on “Seebeck effect” directly. Here there is charge movement in the media. Advantages of Thermoelectric power generators are,

- Small size and less weight.
- Green Technology.
- Increase the overall efficiency (5% to 8%).
- Alternative power sources of energy.
- It requires less space and cost compare to other source waste heat to generate the power is to decrease the cost-per-unit of the devices.

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.

World consciousness of the presence of waste heat in their life has increased day by day. Hundreds of studies on how to recover this wasted thermal energy into a good use were carried all over the countries. In Europe, heat recycling is quite common where Denmark gets half of its electricity from recycled heat, followed by Finland 39%, Russia 31% while US only 12%. Waste heat practically classified into three range of heat which high, intermediate and low. High and intermediate waste heat can be directly recycled into electric power using turbine system while conventional methods such as Organic Rankine Cycle and Kalina Cycle were the typical technologies used for low grade heat conversion. However, due to its complexity and big size installation, the application of these methods is often limited only in transportation and mobile sector. Thus, thermoelectric seems to appear as the most reliable and preferable system choice of all for utilizing low grade heat. Thermoelectric presents a good potential for the conversion of low temperature thermal energy considering its solid-state conversion mode. Additional advantages include no moving parts which contributes to less vibration and noiseless, ability to operate over an extended period of time with minimal maintenance and its capability of operating at elevated temperature.

According to Seebeck, thermoelectric will deliver voltage when there is temperature difference applied on the hot and cold ends of the device. In Seebeck effect, the resulting voltage (V) is proportional to the temperature difference (ΔT) via seebeck coefficient, α ($V = \alpha \Delta T$). Thus, the higher the temperature difference across the device, the higher the electrical power output. Yet, creating temperature difference from low grade heat is rather difficult when the hot temperature itself is already low. Research on thermoelectric application have been started long ago. Not only applied on natural sources of thermal energy, the research has been varied from all sources of wasted heat. One of the most popular research on the application of TEG was recovering heat from exhaust system. About 40% to 70% of thermal energy from exhaust system lost to ambient and it contributes to more fuel usage and low efficiency of the vehicles. In order to solve this problem, TEGs were installed to the surface of exhaust system to utilize the heat.

The major drawback of thermoelectric power generator is their relatively low conversion efficiency (typically ~5%). This has been a major cause in restricting their use in electrical power generation to specialized fields with extensive applications where reliability is a major consideration and cost is not. Applications over the past decade included industrial instruments, military, medical and aerospace and applications for portable or remote power generation. However, in recent years, an increasing concern of environmental issues of emissions, in particular global warming has resulted in extensive research into nonconventional technologies of generating electrical power and thermoelectric power generation has emerged as a promising alternative green technology. Vast quantities of waste heat are discharged into the earth's environment much of it at temperatures which are too low to recover using conventional electrical power generators.

Thermoelectric power generation (also known as thermoelectricity) offers a promising technology in the direct conversion of low-grade thermal energy, such as waste-heat energy, into electrical power. Probably the earliest application is the utilization 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. In this waste heat powered thermoelectric technology, it is unnecessary to consider the cost of the thermal energy input, and consequently thermoelectric power generators' low conversion efficiency is not a critical drawback. In fact, more recently, they can be used in many cases, such as those used in cogeneration systems, to improve overall efficiencies of energy conversion systems by converting waste-heat energy into electrical power.

In general, the cost of a thermoelectric power generator essentially consists of the device cost and operating cost. The operating cost is governed d by the generator's conversion efficiency, while the device cost is determined by the cost of its construction to produce the desired electrical power output. Since the conversion efficiency of a module is comparatively low, thermoelectric generation using waste heat energy is an ideal application. In this case, the operating cost is negligible compared to the module cost because the energy input (fuel) cost is cheap or free. In addition, in designing high performance thermoelectric power generators, the improvement of thermoelectric properties of materials and system optimization have attracted the attention of many research activities. Their performance and economic competiveness appear to depend on successful development of more advanced thermoelectric materials and thermoelectric power module designs.

1.1 Thermoelectric Power Generator

The basic theory and operation of thermoelectric based systems have been developed for many years. Thermoelectric power generation is based on a phenomenon called "Seebeck effect" discovered by Thomas Seebeck in 1821. When a temperature difference is established between the hot and cold junctions of two dissimilar materials (metals or semiconductors) a voltage is generated, i.e., Seebeck voltage. In fact, this phenomenon is applied to thermocouples that are extensively used for temperature measurements. Based on this Seebeck effect, thermoelectric devices can act as electrical power generators.

A simple thermoelectric power generator operating based on Seebeck effect heat is transferred at a rate of Q_H from a high-temperature heat source maintained at T_H to the hot junction, and it is rejected at a rate of Q_L to a low-temperature sink maintained at T_L from the cold junction. Based on Seebeck effect, the heat supplied at the hot junction causes an electric current to flow in the circuit and electrical power is produced. Using the first-law of thermodynamics (energy conservation principle) the difference between Q_H and Q_L is the electrical power output W_e. It should be noted that this power cycle intimately resembles the power cycle of a heat engine (Carnot engine), thus in this respect a thermoelectric power generator can be considered as a unique heat engine.

The studied thermoelectric generator consists of an arrangement of small blocks of bismuth telluride doped with n-type and p-type, mounted alternately, electrically in series, and thermally in parallel between two plates of good thermal conduction, as shown in Figure 1.1. The top of the p-n junction is heated, and the bottom of the set is cooled; in this way, a temperature gradient is generated. The free electrons of the n-type doped elements and the interstices of the p-type elements begin to move toward the cold part, that is, the lower part of the system. In the cold part, the n-type doped elements acquire negative polarity, while the p-type elements get positive polarity. Closing the circuit between the p-n elements, an electric potential is generated with the electron accumulation at the cold side, an internal electric field is created, causing the Seebeck voltage.

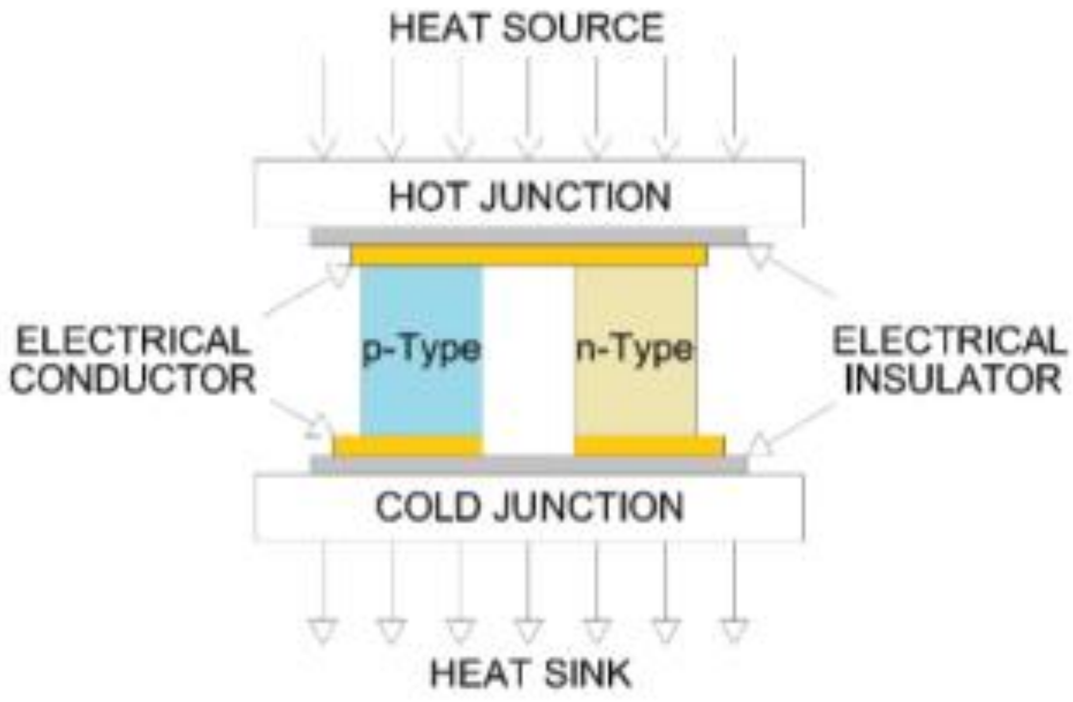

Figure 1.1: Schematic diagram of a thermoelectric generator.

With the energy and environmental issues increasingly prominent, the challenge of fossil energy depletion and environmental pollution, the renewable energy has become more and more important to human. The thermoelectric (TE) generation technology as one of the renewable generation methods has widely been used in various industries and situations. Especially, the waste heat usually has been ignored and abandoned. If the waste heat could be utilized effectively by the TE generation technology as the thermal energy, that will break the routine energy utilization and create a new sight of energy storage.

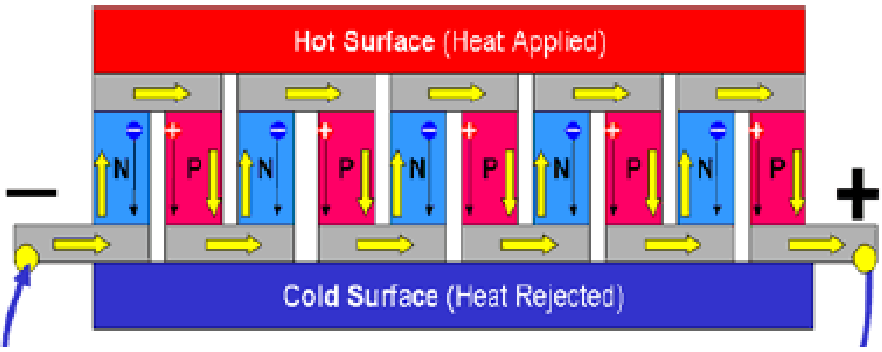

Figure 1.2: Schematic of a thermoelectric generator.

TEG can be used in , Jet Engine parts, IC Engines parts, Furnace cover, Hot water tubes, Refrigerator Computer/laptop Body heat etc when "electrons" are in motion, we have an electrical current (i.e., charge per unit time per unit area).electrical voltage ("pressure") usually is the driving force but, other forces like temperature difference and hence flow of thermal energy/heat can drive the electrons. In 1821, J. T. Seebeck (1770-1831) discovered that dissimilar metals that are connected at two different locations (junctions) will develop a micro-voltage if the two junctions are held at different temperatures. This effect is known as the "Seebeck effect" The use of both N and P type materials in a single power generation device allows us to truly optimize the Seebeck effect. As shown in Figure 1.2, the N and P pellets are configured thermally in parallel, but electrically in a series circuit. Because electrical current (i.e., moving electrons) flows in a direction opposite to that of the hole flow, the current generating potentials in the pellets do not oppose one another, but are series-aiding. Thus, if each pellet developed a Seebeck voltage of 20mV, this combination of an N pellet and a P pellet would generate approximately 40Mv.

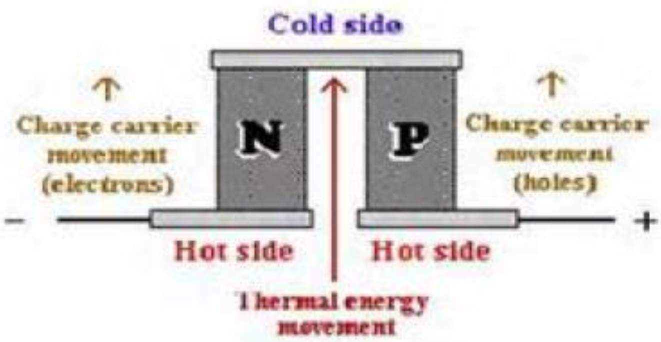

Figure 1.3: Background of the thermoelectric chip.

In recently years, with the improvement in the efficiency of TE energy conversion, TEGs interest us through the implementation to solar energy, vehicle and human diagnosis devices. Firstly, the solar energy as a green and cost-effective renewable energy has been utilized in recent years. There was an energy harvesting system that could not only collect both solar and thermal energies with a solar tracking system, but also convert the thermal energy to electrical energy by the TEG. Thus, the proposed system was reported to enhance the conversion efficiency to 38.65%. Secondly, there are about 40%-70% thermal energy lost through the exhaust system in gasoline engines of most vehicles. In order to reduce the fuel usage and increase the efficiency of the vehicle, the waste heat has been transmitted to the TEG's hot side, which is installed at the surface of the exhaust system. Thirdly, the applications of the intelligent wearable technology have been developed rapidly; especially it plays a significant role in the healthcare field. A flexible supercapacitor was developed to store the electrical energy from human body's heat energy through the TEG, which cannot only monitor the human's health, but also supply the power to other wearable devices.

Unfortunately, compared to the thermal power generation, the efficiency of TEG is much lower. Thus, it tends to be used in low-power applications. Furthermore, since the temperature gradient cannot be controlled in most working environment, the output voltage also varies. Therefore, the voltage regulator circuit must be designed in the TEG system.

1.2 Problem Definition

Some developing countries and most populated industrialized countries 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 demand. 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. 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 without light Now a days consumer demand is more than the power production that is the major difficulty to overcome.

1.3 Problems Facing

- Efficient heat conduction and evenly heat transfer should be there.
- Temp difference between the two junctions should be maintained, but at higher temperatures, heat transfers between one junction to other.
- Voltage generated is less.

1.3.1 Solutions to these Problems

- Using Aluminium/ Copper sheets and ensuring even thermal conductivity using thermal conductive paste.
- Isolation of the junction is maintained by using silicon glue.
- Using TEG modules in series to generate effective voltage and using dc to dc boost converter.

1.4 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. The control mechanism carries regulator circuit etc and the power saving mechanism carries microcontroller relays etc.

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

1.5 Scope of the Study

The scopes of project study are;

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

1.6 Summary

The chapter concludes by giving a brief introduction to TEG, present problem in controlling the power and which is followed by the proposed system and advantages of the project.

Chapter 2

LITERATURE SURVEY

[1]Prashantha K, Sonam Wango, they discussed the generating electricity in present there is a shortage of fossil fuel, oil, gas, etc. burning of these fuels causes environmental problem like radio activity pollution, global warming etc. So that these (coal, oil, gas) are the limiting resources hence resulting new technology is needed for electricity generation, by using thermoelectric generators to generate power as a most promising technology and environmental free and several advantages in production. Thermoelectric generator can convert directly thermal (heat) energy into electrical energy. In this TEG there are no moving parts and it cannot be producing any waste during power production hence it is considered as a green technology. Thermoelectric power generator converts direct waste heat in to generate electricity. 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. This method will have a maximum outcome. 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. By using this energy is used to charge the mobile electronics.

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.

[2]M. F Remelia, L. Kiatbodina, B. Singh, K. Verojporna, A. Datea, they discussed the investigation of power generation using the combination of heat pipes 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. The laboratory experiment of the proposed system was obtained with a counter flow air duct heat exchanger. The results obtained show an increase in the ratio of mass flow rate in upper duct to lower duct has a positive effect on the overall system performance. A higher mass flow rate ratio results in a higher amount of heat transfer and higher power output.

[3]Hema. S, Vinodini. D, they discussed the generating electricity in present there is a shortage of fuel, oil, gas, etc. burning of those fuels causes environmental problem like radio activity pollution, heating etc. so these (coal, oil, gas) limiting resources therefore ensuing new technology is required for electricity generation, by exploitation thermo electrical generators to get power as a most promising technology and environmental free and a number of other benefits in production. Thermo electrical generator will convert directly thermal (heat) energy into voltage. In this TEG there are not any moving elements and it can't be turn out any waste throughout power production and hence it is considered as a green technology. Thermo electrical power generation supply a possible application within the direct exchange of waste-heat energy into electric power wherever it's surplus to believe the value of the thermal energy input. This technique can have associate most outcome. the appliance of this selection inexperienced technology in changing waste-heat energy directly into electric power will too improve the efficiencies of energy conversion systems.

[4]Basel I. Ismail, Wael H. Ahmed, they discussed 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. Thermoelectric power generation offer a potential application in the direct conversion of waste-heat energy into electrical power where it is unnecessary to consider the cost of the thermal energy input. The application of this alternative green technology in converting waste-heat energy

directly into electrical power can also improve the overall efficiencies of energy conversion systems. 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.

[5]Shrutika Karpe, they discussed the 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. But out of them energy would relate to the manageability of the cost or potential cost savings and thus energy management will help in cost reduction. 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. 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. Even though output of TEGs are low with available techniques, feasible electricity generation is possible due to waste heat emitted from the automobile (internal combustion engine operation).

Waste heat recovery entails capturing and reusing the waste heat from 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 formation of 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.

[6]Navnath D. Ganjwe, Sandip S. Jawre, they discussed 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. Thermoelectric power generation offer a potential application in the direct conversion of thermal energy by combusting municipal inorganic waste garbage into direct electrical power generation, where it is unnecessary to consider the cost of the thermal energy input. Generating electricity in present there is a shortage of fossil fuel, oil, gas, etc. burning of these fuels causes environmental problem like radio activity pollution, global warming etc. So that these (coal, oil, gas) are the limiting resources hence resulting new technology is needed for electricity generation, by using thermoelectric generators to generate power as a most promising technology and environmental free and several advantages in production. Thermoelectric generator can convert directly thermal (heat) energy into electrical power. In this TEG there are no moving parts and it cannot be producing any waste during power production hence it is considered as a green technology.

[7]P. Mohan Kumar, I. Kathiravan, G. Aadhithyan, they discussed the electricity is most important one of the human life and industries. But the available energy is very less. Today the demand of energy is increasing tremendously, but available energy lacks in supply. This problem is overcome by this project. In this paper the main stress is given on energy conservation by using technique of utilizing waste heat from Refrigerator/Air conditioning system. The refrigeration system always tends to produce an excess of low temperature heat which is commonly referred to as "waste heat". In this heat which is lost to the environment, however, may be recovered to a certain extent and reused to our advantage instead. A possible way of reutilization of the wasted energy has been thought of the device which are capable for converts this heat into useful form like electricity. The mechanism and design such a device, which is connected to the refrigeration system, it utilizes the waste heat for generation of electricity has been done. In this case, we have considered the waste heat is a heat source and the principle of thermoelectricity has been used.

Energy is a basic requirement for the existence and development of human life. Waste heat recovery and utilization is the process of capturing and reusing waste heat for a useful purpose. Waste heat which is rejected from a process at a temperature enough high above the ambient temperature permits the recovery of energy. From the research found out that by amount of electrical energy is found from domestic refrigerator and the hot case can be saved. By using the method of energy conservation can improves the thermal efficiency of the system should be obtained from the research. The pyroelectric waste heat should be produced from the waste heat conduction.

[8]Luis Vitorio Gulineli Fachini, Pedro Leineker Ochoski Machado, they discussed an experimental analysis of the direct conversion of thermal energy into electric energy was carried out, in order to encourage the conscious use of energy and to reduce waste. The conversion of thermal energy into electrical energy occurs in a thermoelectric generator through the Seebeck effect. This effect is associated with the appearance of an electric potential difference between two different materials, placed in contact at different temperatures. This relation between temperature and electrical properties of the material is known as thermoelectricity. This experimental study has as objective the obtaining of operating characteristic curves of the thermoelectric generator TEG1-12611-6.0 for different temperature gradients and under constant pressure between the heater plate and the heat sink. Resistors were used to heat the thermoelectric generator, which simulates the residual heat, and insulation material to minimize the dissipation of heat to the environment. For cooling, a heat exchanger was used in order to maximize the temperature difference between the sides of the thermoelectric generator. In this way, it was possible to perform an experimental analysis of the obtained electric power for different temperature ranges between the faces of the generator and, with this, verify the applicability in real systems.

[9]Li Siyang, K. H. Lam, Cheng, they discussed the development of the thermoelectric (TE) power generation is rapidly conducted as well as the application areas are increasingly. Its principle is based on the Seebeck effect that uses the temperature difference between the hot side and cool side of the thermoelectric generator (TEG) to convert thermal energy to electrical energy. A new design proposed here is to convert the waste heat from a motor of electric vehicle (EV) to the electrical energy by the TEGs. Furthermore, the electrical energy generated could be supplied to the LED lights of the EV or to charge the supercapacitor or the battery. All the system has been described in detail. The TEG technology, its advantage and disadvantage are reported. The electrical and control model of the TEG have also been proposed.

A motor waste heat power generation system based on the TEGs has been studied. The paper firstly develops the mathematical model to analyse the characteristic of the

TEG. Moreover, the buck converter has been developed for the power control of TEG. An equation has been obtained such that the maximum output power could be maintained when the load voltage is equal to half of open circuit voltage. Secondly, the power generation system based on TEGs has been designed and developed successfully. The waste heat of motor was harvested from TEGs to offer the electrical energy for low power units, such as LED lights for the EV. There are still rooms to further explore the system, for example, the enhancement of efficiency from materials of TEGs, the improvement of heat transfer mechanism from motor surface to TEGs. It is expected that TE power generation will create a new era of static power conversion.

[10]Ravi Anant Kishore, Shashank Priya, they discussed the combined rejected and naturally available heat constitute an enormous energy resource that remains mostly untapped. Thermal energy harvesting can provide a cost-effective and reliable way to convert available heat into mechanical motion or electricity. This extensive review analyses the literature covering broad topical areas under solid-state low temperature thermal energy harvesting. Technical advancements reported in the literature are utilized to analyse the performance, identify the challenges, and provide guidance for material and mechanism selection. The review provides a detailed analysis of advantages and disadvantages of each energy harvesting mechanism, which will provide guidance towards designing a hybrid thermal energy harvester that can overcome various limitations of the individual mechanism. Waste heat and natural heat constitute an enormous energy reserve that can be used to generate electricity in order to fulfil the growing energy demand.

[11]E F Thacher, B T Helenbrook, M A Karri, C J Richter, they discussed the testing was conducted on a prototype automobile exhaust thermoelectric generator (AETEG) installed in a 1999 GMC Sierra pick-up truck. The system consisted of the generator, its power conditioning unit, and the interfaces to the test truck's engine coolant and exhaust systems. The objective of the test was to measure the AETEG's performance and its effect on the truck systems as well as to determine which factors are important for optimizing an AETEG design. The prototype AETEG was installed and three configurations of the system were tested. The AETEG alone, the AETEG with portions of the exhaust pipes leading to it insulated, and the AETEG with insulated upstream exhaust pipes and with a pre-cooling heat exchanger operating to lower the inlet coolant temperature to the generator. Some of the important outcomes of the tests were: insulating

the exhaust and lowering the coolant temperature had a significant positive effect on the power, parasitic losses resulting from the AETEG weight and the coolant pumping power were significant but manageable, and the increased exhaust flow resistance and the additional heat load from the AETEG were not significant effects. Renewed interest in applications of thermoelectric designed technology is being driven by laboratory tests of thermocouples made of thin-film quantum well materials. These tests have suggested a potential conversion efficiency of about 22–24 per cent. This efficiency is comparable to the average thermal efficiency of gasoline-fuelled passenger vehicles and light trucks. However, as the results reported herein emphasize, the design of the entire generator system is critical to realizing this efficiency.

[12]Yuchao Wanga, Chuanshan Dai, Shixue Wang, they discussed the Fourier's law and the Seebeck effect, this paper presents a mathematical model of a Thermoelectric Generator (TEG) device using the exhaust gas of vehicles as heat source. The model simulates the impact of relevant factors, including vehicles exhaust mass flow rate, temperature and mass flow rate of different types of cooling fluid, convection heat transfer coefficient, height of PN couple, the ratio of external resistance to internal resistance of the circuit on the output power and efficiency. The results show that the output power and efficiency increase significantly by changing the convection heat transfer coefficient of the high-temperature-side than that of low-temperature-side. The results also show that with variation in the height of the PN couple, the output power occur a peak value, and the peak value decreases when decreasing the thermal conductivity of the PN couple, and increases when increasing the Seebeck coefficient and electric conductivity of the material. Meanwhile, a maximum output power and efficiency of a TEG appear when external resistance is greater than internal resistance. This is different from a common circuit, and with the increment of ZT, the maximum value moves toward the direction of an increasing ratio of external resistance to internal resistance.

[13]K Julaihie, R Abu Bakar, B Bhathal Singh, M Remeli1, A Oberoi, they discussed the power generation from low grade heat energy sources have been increasing rapidly as it will be beneficial towards environment, human lives and also for long term sustainability. Due to its biggest potential and advantages, thermoelectric generator has been reliably used to generate electricity. An experiment on power generation using thermoelectric generator by employing low grade heat (<150 ˚C) energy source was carried out. The main purpose of this project was to generate useful electricity using

thermoelectric generator and to investigate the quality of heat exchanger in enhancing the performance of thermoelectric generator. A prototype heat exchanger was used to carry out this experiment. The heat exchanger was tested with varied hot and cold-water supply to study the effect of temperature difference on the thermoelectric generators. The highest output power obtained was 0.98 W and the maximum efficiency was 1.91%.

2.1 Summary

This chapter gives brief details about the literature survey for the project which gives concepts about TEG in the generation of the power, controlling.

Chapter 3

METHODOLOGY

This section gives the brief description of each component used in designing the waste heat to generate electricity By using this thermoelectric power generation (TEPG) TEC12706 devices shown whenever 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 versa in such a way that the other side of thermoelectric generator is cold because heat transform is uniform then only electron will flow and voltage is developed at the output side of the thermoelectric generator. In this part voltage from the TEG is regulated by required voltage for mobile charger.

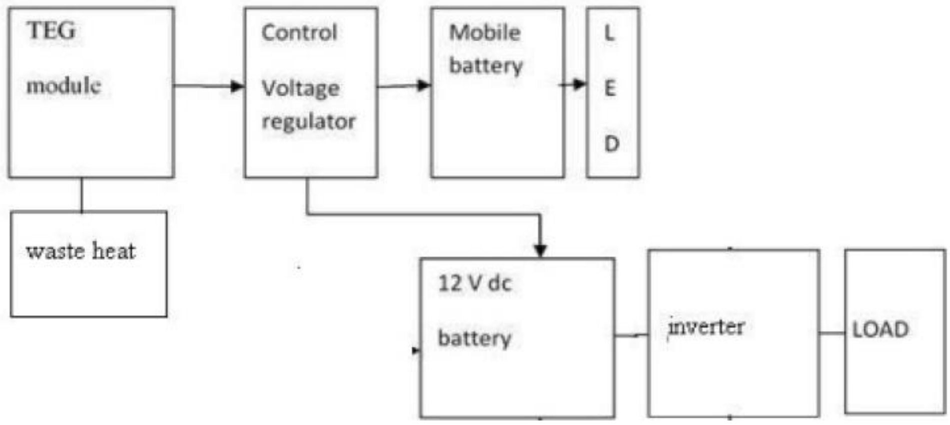

Figure 3.1: Block diagram Voltage regulator (control circuit)

3.1 Components Required

Generic TEG 150-degree high temperature 40x40mm thermoelectric power Generator peltier module.

Table 3.1:Specifications of TEG SP1848-27145

Model	*SP1848-27145*
Open Circuit Voltage (V)	*4.8*
Operating Temperature (°C)	*0 to 120*
Maximum Temperature(°C)	*120*
Wire Length(mm)	*350*
Length (mm)	*40*
Width (mm)	*40*
Height (mm)	*3.6*
Weight(gm)	*30*
Shipment Weight	*0.125 kg*
Shipment Dimensions	*5 × 5 × 5 cm*

Figure 3.2: TEG SP1848-27145

TEG SP1848-27145 spec sheet

Temperature (°C)	20	40	60	80	100
Open circuit voltage (V)	0.97	1.8	2.4	3.6	4.8
Current (mA)	225	368	469	558	669

Hub 0.9-5V dc to 5V dc step up converter dc-dc power boost module board with USB output.

Specification:

- Input Voltage:0.9-5V;Output voltage:5V
- Maximum Output Current:600mA
- Starting Up Voltage:0.9V;output current:7mA
- Input Voltage:1-1.5V;output voltage 5V;current 40-100mA
- Input Voltage:1.5-2V;output voltage 5V;current 100-150mA
- Input Voltage:2-3V;output voltage 5V;current 150-380mA

- Input Voltage:>3V;output voltage 5V;current 380-600mA
- Typical Conversion Efficiency:96%

Figure 3.3: DC-DC power boost module.

- Fedus 10g grey heat sink compound thermal silicon conductive grease paste.

Figure 3.4: Thermal silicon conductive grease paste.

- Artefact 2 pieces of 36-gauge half hard copper sheet.

Figure 3.5: 36-gauge half hard copper sheet.

3.2 Circuit Diagram and Working by Using TEG

The Buck step-up DC-DC switching regulators for small, low input voltage or battery-powered systems.

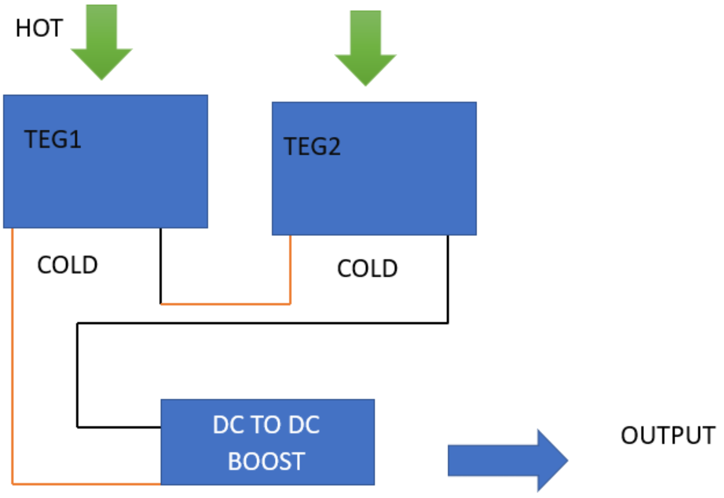

Figure 3.6: TEG working principle.

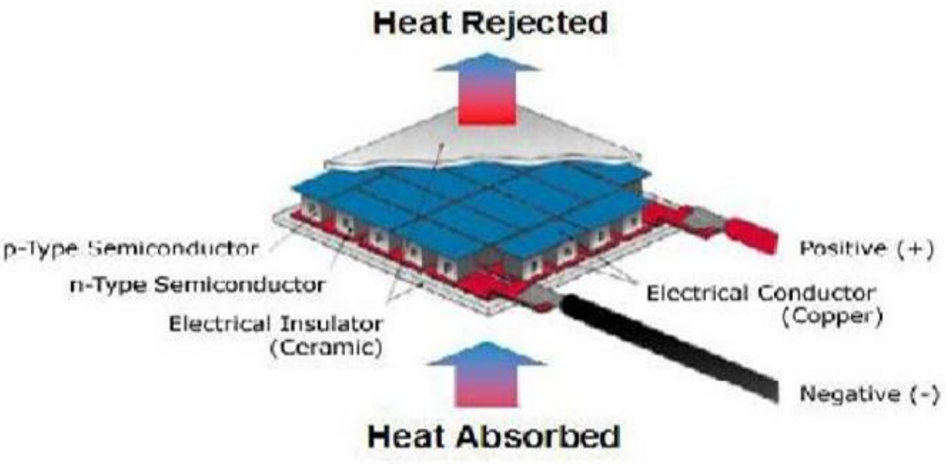

Figure 3.7: Schematic diagram of a thermoelectric generator.

Seebeck Effect Jon seebeck invented the new designed circuit consisting of two (cold and hot side) different thermal conducting materials, whose connections based on the different temperatures. In case of a Peltier cooler module the Seebeck voltage can be determined by below equation,

$$VS = \alpha \, (Th - Tc)$$

where Th-Tc is the temp difference between heat applied and cold side of TEG.

TEG components

i. Thermoelectric internal elements
ii. Thermoelectric covering
iii. Thermal withstanding
iv. Copper wire

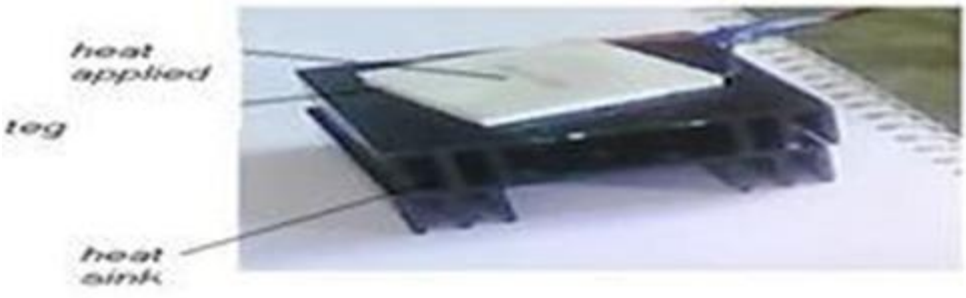

Figure 3.8: Thermoelectric generator with fin heat sink

3.3 Circuit Diagram of MAX756

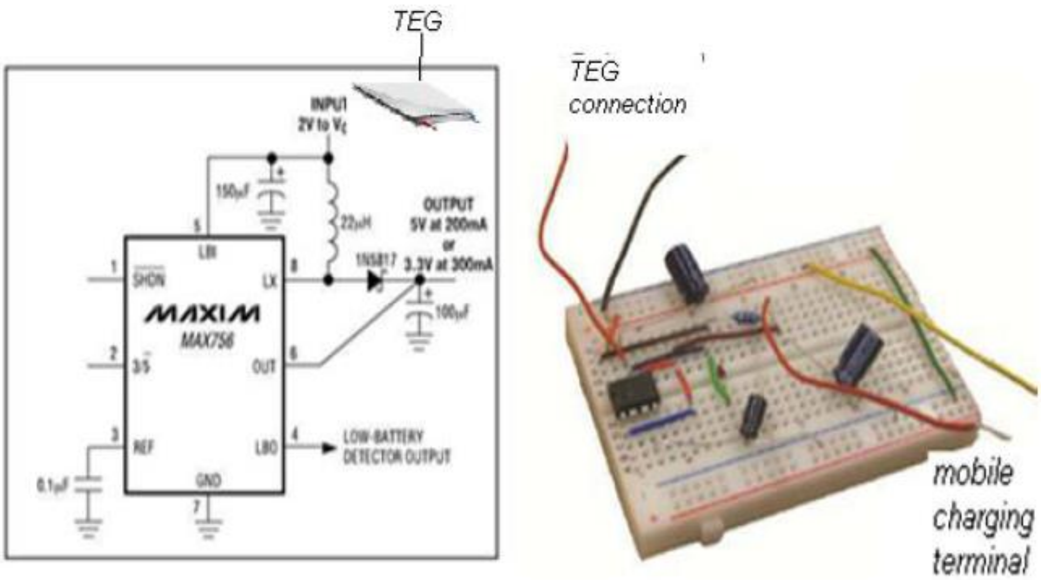

Figure 3.9: Circuit diagram of Volt From 1.5 Volt Circuit Schematic

The MAX756/MAX757 are CMOS step-up DC-DC switching regulators for small, low input voltage or battery-powered systems. The MAX756 accepts a positive input voltage down to 0.7V and converts it to a higher pin-selectable output voltage of 3.3V or 5V. The MAX757 is an adjustable version that accepts an input voltage down to 0.7V and generates a higher adjustable output voltage in the range from 2.7V to 5.5V. Typical full-load efficiencies for the MAX756/MAX757 are greater than 87%. Max756 combine a switch-mode regulator with an N channel MOSFET, precision voltage reference, and power-fail detector in a single monolithic device. The MOSFET is a "sense-FET" type for best efficiency, and has a very low gate threshold voltage to ensure start-up under low-battery voltage conditions (1.1V type). The circuit can be easily wired on a very small rectangular common PCB. All connections should be kept as short as possible. If available, try to add a good quality 8 pin DIP socket for IC1. Note that the power inductor's (L1) DC resistance significantly affects efficiency. For highest efficiency, limit L1's DC resistance to 0.03 Ohm or less. A thru-hole type standard power inductor can be used. Similarly, the ESR of all capacitors (bypass and filter) affects circuit efficiency. Best performance is obtained by using specialized low-ESR capacitors.

3.4 Lithium-ion battery

A lithium-ion battery or Li-ion battery (abbreviated as LIB) is a type of rechargeable battery. Lithium-ion batteries are commonly used for portable electronics and electric vehicles and are growing in popularity for military and aerospace applications. Batteries are the most common power source for basic handheld devices to large scale industrial applications. A battery can be defined as; it is a combination of one or more electrochemical cells that are capable of converting stored chemical energy into electrical energy.

In the batteries, lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. The batteries have a high energy density, no memory effect (other than LFP cells) and low self-discharge. They can however be a safety hazard since they contain a flammable electrolyte, and if damaged or incorrectly charged can lead to explosions and fires. Research areas for lithium-ion batteries include extending lifetime, increasing energy density, improving safety, reducing cost, and increasing charging speed among others. Research has been under way in the area of non-flammable electrolytes as a pathway to increased safety based on the flammability and volatility of the organic solvents used in the typical electrolyte. Strategies include aqueous lithium-ion batteries, ceramic solid electrolytes, polymer electrolytes, ionic liquids, and heavily fluorinated systems.

Batteries with a lithium iron phosphate positive and graphite negative electrodes have a nominal open-circuit voltage of 3.2 V and a typical charging voltage of 3.6 V. Lithium nickel manganese cobalt (NMC) oxide positives with graphite negatives have a 3.7 V nominal voltage with a 4.2 V maximum while charging. The charging procedure is performed at constant voltage with current-limiting circuitry (i.e., charging with constant current until a voltage of 4.2 V is reached in the cell and continuing with a constant voltage applied until the current drops close to zero). Typically, the charge is terminated at 3% of the initial charge current. In the past, lithium-ion batteries could not be fast-charged and needed at least two hours to fully charge. Current-generation cells can be fully charged in 45 minutes or less. In 2015 researchers demonstrated a small 600 mAh capacity battery charged to 68 percent capacity in two minutes and a 3,000 mAh battery charged to 48 percent capacity in five minutes. The latter battery has an energy density of 620 Wh/L. The device employed heteroatoms bonded to graphite molecules in the anode.

Performance of manufactured batteries has improved over time. For example, from 1991 to 2005 the energy capacity per price of lithium ion batteries improved more than ten-fold, from 0.3 Wh per dollar to over 3 Wh per dollar. In the period from 2011–2017, progress has averaged 7.5% annually. Differently sized cells with similar chemistry also have the same energy density. The 21700 cell has 50% more energy than the 18650 cell, and the bigger size reduces heat transfer to its surroundings.

Figure 3.10: Li-ion 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

3.4.1 Advantages of Lithium Ion Battery

Lithium Ion batteries outperform NiCd batteries and other secondary batteries. Some of the advantages are

- Light weight compared to other batteries of similar size
- Available in different shape including Flat shape
- High open circuit voltage that increases the power transfer at low current
- Lack of memory effect.
- Very low self-discharge rate of 5-10% per month. Self-discharge is around 30% in NiCd and NiMh batteries.
- Eco-friendly battery without any free lithium metal

3.5 Light-Emitting Diode (LED)

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting. The LED consists of a chip of semiconducting material doped with impurities to create a p-n junction. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode, but not in the reverse direction. Charge carrier's electrons and holes flow into the junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon.

The wavelength of the light emitted, and thus its color depends on the band gap energy of the materials forming the p-n junction. In silicon or germanium diodes, the electrons and holes recombine by a non-radiative transition, which produces no optical emission, because these are indirect band gap materials. The materials used for the LED have a direct band gap with energies corresponding to near-infrared, visible, or near-ultraviolet light.

3.5.1 Working

The construction of LED is shown in figure 5.14 an N-type epitaxial layer is grown upon a substrate, and the P-region is produced by diffusion. The P-region that includes the recombination of charge carriers is shown is the top. Thus, the P-region becomes the device surface.

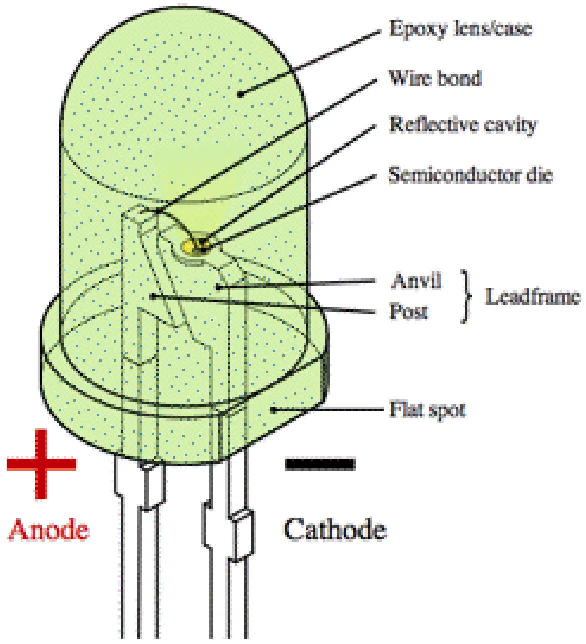

Figure 3.11: Construction of LED

In order to allow more surface area for the light to be emitted the metal anode connections are made at the outer edges of the P-layer. For the light be reflected as much as possible towards the surface of the device, a gold films applied to the surface bottom. This setting also enables to provide a cathode connection. The reabsorption problem is fixed by including domed lenses for the device. All the wires in the electronic circuits of the device is protected by encasing the device. The light emitted by the device depends on the type of semiconductor material used.

Infrared light is produced by using Gallium Arsenide (GaAs) as semiconductor. Red or yellow light is produced by using Gallium-Arsenide-Phosphorus (GaAsP) as semiconductor. Red or green light is produced by using Gallium-Phosphorus (GaP) as semiconductor.

3.5.2 Advantages of LED’s

- Very low voltage and current are enough to drive the LED.
- Voltage range 1 to 2 volts and current 5 to 20 mill amperes.
- Total power output will be less than 150 mill watts.
- The response time is very less only about 10 nanoseconds.
- The device does not need any heating and warm up time.
- Miniature in size and hence light weight.
- Have a rugged construction and hence can withstand shock and vibrations.

3.6 Waste Heat

Waste heat is heat that is produced by a machine, or other process that uses energy, as a by-product of doing work. All such processes give off some waste heat as a fundamental result of the laws of thermodynamics. Waste heat has lower utility (or in thermodynamics lexicon a lower exergy or higher entropy) than the original energy source. Sources of waste heat include all manner of human activities, natural systems, and all organisms, for example, incandescent light bulbs get hot, a refrigerator warms the room air, an internal combustion engine generates high-temperature exhaust gases, and electronic components get warm when in operation.

Instead of being "wasted" by release into the ambient environment, sometimes waste heat (or cold) can be utilized by another process (such as using hot engine coolant to heat a vehicle), or a portion of heat that would otherwise be wasted can be reused in the same process if make-up heat is added to the system (as with heat recovery ventilation in a building). Thermal energy storage, which includes technologies both for short- and long-term retention of heat or cold, can create or improve the utility of waste heat (or cold). One example is waste heat from air conditioning machinery stored in a buffer tank to aid in night time heating. Another is seasonal thermal energy storage (STES) at a foundry in Sweden. The heat is stored in the bedrock surrounding a cluster of heat exchanger equipped boreholes, and is used for space heating in an adjacent factory as needed, even months later. An example of using STES to utilize natural waste heat is the Drake Landing Solar Community in Alberta, Canada, which, by using a cluster of boreholes in bedrock for inter seasonal heat storage, obtains 97 percent of its year-round heat from solar thermal collectors on the garage roofs. Another STES application is storing winter cold underground, for summer air conditioning. On a biological scale, all organisms reject waste heat as part of their metabolic processes, and will die if the ambient temperature is too high to allow this.

Anthropogenic waste heat is thought by some to contribute to the urban heat island effect. The biggest point sources of waste heat originate from machines (such as electrical generators or industrial processes, such as steel or glass production) and heat loss through building envelopes. The burning of transport fuels is a major contribution to waste heat.

3.6.1 Waste Heat to Electricity

There are many known ways to convert a temperature difference into electrical energy. One approach is by using a thermoelectric device, where a change in temperature across a semiconductor material creates a voltage that causes electricity to flow, sometimes referred to as the Peltier-Seebeck effect. This device is still subject to the limits imposed by the second law of thermodynamics. In other words, this is a way to approach the Carnot engine limit, but not surpass it.

3.6.2 Sources

In the majority of energy applications, energy is required in multiple forms. These energy forms typically include some combination of: heating, ventilation, and air conditioning, mechanical energy and electric power. Often, these additional forms of energy are produced by a heat engine, running on a source of high-temperature heat. A heat engine can never have perfect efficiency, according to the second law of thermodynamics, therefore a heat engine will always produce a surplus of low-temperature heat. This is commonly referred to as waste heat or "secondary heat", or "low-grade heat". This heat is useful for the majority of heating applications; however, it is sometimes not practical to transport heat energy over long distances, unlike electricity or fuel energy. The largest proportions of total waste heat are from power stations and vehicle engines. The largest single sources are power stations and industrial plants such as oil refineries and steelmaking plants.

3.6.3 Power generation

The electrical efficiency of thermal power plants is defined as the ratio between the input and output energy. It is typically only 33% when disregarding usefulness of the heat output for building heat. The images show cooling towers which allow power stations to maintain the low side of the temperature difference essential for conversion of heat differences to other forms of energy. Discarded or "Waste" heat that is lost to the environment may instead be used to advantage.

- Coal-fired power station that transform chemical energy into 36%-48% electricity and remaining 52%-64% to waste heat.
- Industrial processes, such as oil refining, steel making or glass making are major sources of waste heat.
- Electronics: Although small in terms of power, the disposal of waste heat from microchips and other electronic components, represents a significant engineering challenge. This necessitates the use of fans, heatsinks, etc. to dispose of the heat.
- Biological: Animals, including humans, create heat as a result of metabolism. In warm conditions, this heat exceeds a level required for homeostasis in warm-blooded animals, and is disposed of by various thermoregulation methods such as sweating and panting.

3.6.4 Applications

- Traditionally, waste heat of low temperature range (0-120 °C, or typically under 100 °C) has not been used for electricity generation despite efforts by ORC companies, mainly because the Carnot efficiency is rather low (max. 18% for 90 °C heating and 20 °C cooling, minus losses, typically ending up with 5-7% net electricity).
- Waste heat of medium (120-650 °C) and high (>650 °C) temperature could be used for the generation of electricity or mechanical work via different capturing processes.
- Waste heat recovery system can also be used to fulfill refrigeration requirements of a trailer (for example). The configuration is easy as only a waste heat recovery boiler and absorption cooler are required. Furthermore, only low pressures and temperatures needed to be handled.

3.6.5 Indirect benefits

Reduced Pollution: Thermal and air pollution will dramatically decrease since less flue gases of high temperature are emitted from the plant since most of the energy is recycled.

Reduced equipment sizes: As Fuel consumption reduces so the control and security equipment for handling the fuel decreases. Also, filtering equipment for the gas is no longer needed in large sizes.

Reduced auxiliary energy consumption: Reduction in equipment sizes means another reduction in the energy fed to those systems like pumps, filters, fans, etc.

Disadvantages

- Capital cost to implement a waste heat recovery system may outweigh the benefit gained in heat recovered. It is necessary to put a cost to the heat being offset.
- Often waste heat is of low quality (temperature). It can be difficult to efficiently utilize the quantity of low-quality heat contained in a waste heat medium.

- Heat exchangers tend to be larger to recover significant quantities which increases capital cost.
- Maintenance of Equipment: Additional equipment requires additional maintenance cost.
- Units add size and mass to overall power unit. Especially a consideration on mobile power units on vehicles.

3.7 Summary

This chapter gives brief details about the system architecture for the project which gives concepts about waste heat generation, benefits of TEG and power generation requirements for the project implementation.

Chapter 4

FUTURE DEVELOPMENTS

Recently, an increasing concern of environmental issues of emissions, in particular global warming and the constraints on energy sources has resulted in extensive research into innovative technologies of generating electrical power and thermoelectric power generation has emerged as a promising alternative green technology. In addition, vast quantities of waste heat are discharged into the earth's environment much of it at temperatures which are too low (i.e. low-grade thermal energy) to recover using conventional electrical power generators. Thermoelectric power generation offers a promising technology in the direct conversion of waste-heat energy, into electrical power.

Currently, waste heat powered thermoelectric generators are utilized in a number of useful applications due to their distinct advantages. These applications can be categorized as micro- and macro-scale applications depending on the potential amount of heat waste energy available for direct conversion into electrical power using thermoelectric generators. Micro-scale applications included those involved in powering electronic devices, such as microchips. Since the scale at which these devices can be fabricated from thermoelectric materials and applied depends on the scale of the miniature technology available. Therefore, it is expected that future developments of these applications tend to move towards nano technology.

The macro-scale waste heat applications included: domestic, automobiles, industrial and solid waste. Currently, enormous amounts of waste heat are discharged from industry, such as manufacturing plants and power utilities. Therefore, most of the recent research activities on applications of thermoelectric power generation have been directed towards utilisation of industrial waste heat. Future developments in this area might focus onto finding more suitable thermoelectric materials that could handle higher temperatures from various industrial heat sources at a feasible cost with acceptable performance. Another future direction is to develop more novel thermoelectric module geometries and configurations.

The developments of more thermoelectric module configurations by developing novel flexible thermoelectric materials will make them more effective and attractive in applications where sources of waste heat have arbitrary shapes.

Chapter 5

TEST AND RESULT ANALYSIS

An emissivity apparatus was used for the experiment which had an electric heater with a knob to adjust the heat supplied, thermocouples to measure the temperature at the bottom surface of the TEG module. An aluminium heat exchanger was fabricated to improve cooling on the other side of the module to create a higher temperature gradient which would result in higher power generation from the TEG module. A multi meter was used to measure the current and voltage output from the leads of the module.

Testing by using waste heat as an iron box: Complete setup to charge the mobile battery by using thermoelectric generator complete setup to charge the mobile battery is shown in figure 5.1. When heat is applied to the hot side the TEG get absorb the heat from anybody (refrigerator 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 5.1.

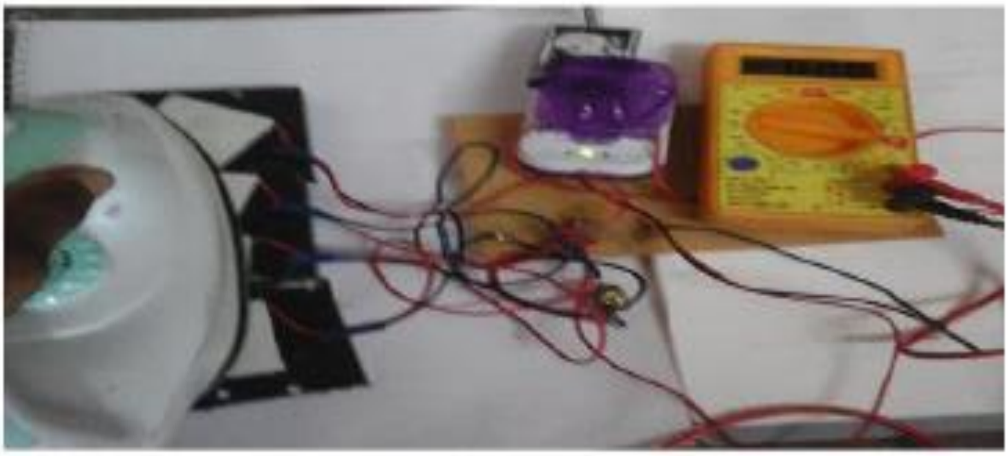

Figure 5.1: Charging the sample mobile battery using TEG by waste heat.

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 needs 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 its ill glow when the output voltage is above 3.5 volt.

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 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. Figure 5.2. 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.

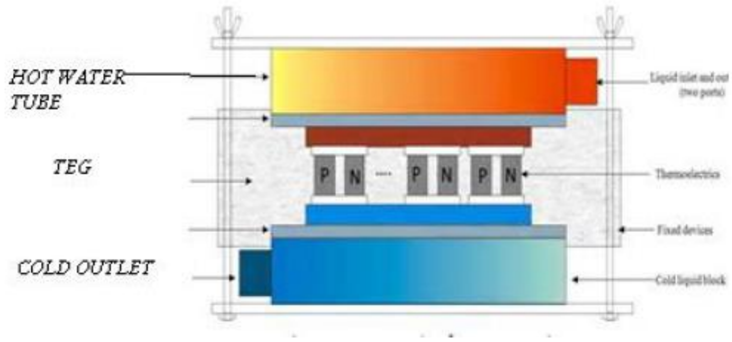

Figure 5.2: Shows the schematic of the module tests.

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.

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. Figure 5.3 shows one example of such a system.

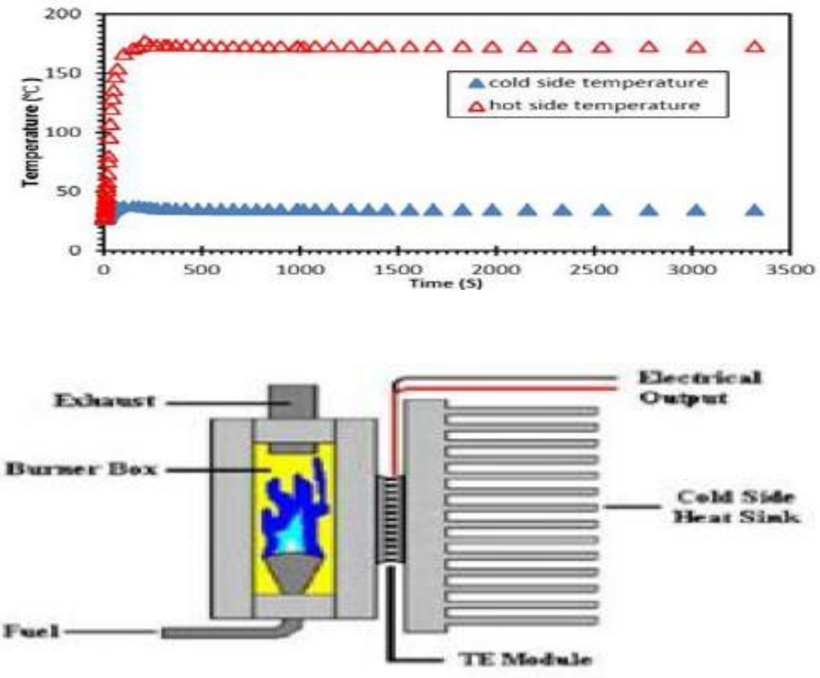

Figure 5.3: Shows one example of such a system.

5.1 Result Analysis

Primarily waste heat is used to charge the battery. The system is tested to meet the desired objectives and the on a hot chamber plate (body heat or iron box I am using here to get fast output and the aluminium 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°Cto220°C. 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)

Table 5.1: Performances of TEG module

Temperature in °C	Voltage in mV	Current in mA	Power in mW
35	21.8	1	0.0218
45	443	1.9	0.8417
55	486	5.4	2.6244
65	508	13	6.6040
75	570	24.9	14.1930
85	645	36	23.2200
95	742	52	38.5840
105	848	76.8	65.1264
115	1102	96.4	106.233
125	1348	121.4	163.647
135	1678	168	281.904
145	2080	206	428.480
150	2287	231	528.297
155	2500	260	650.000

The heater in the emissivity apparatus was used to heat the bottom side of the emissivity module. Readings of voltage and current output from the TEG module were taken using a multi meter from 35 degree Celsius onwards for every 10 degree rise in temperature. This was continued until a temperature of 145 degree Celsius was reached.

During the experiment the temperature was varied from 35o C to 155o C. We observed increased in power output with the increase in temperature. The variation of power, current and voltage produced by the TEG are plotted against the temperature in the figures 5.4, 5.5 and 5.6 respectively.

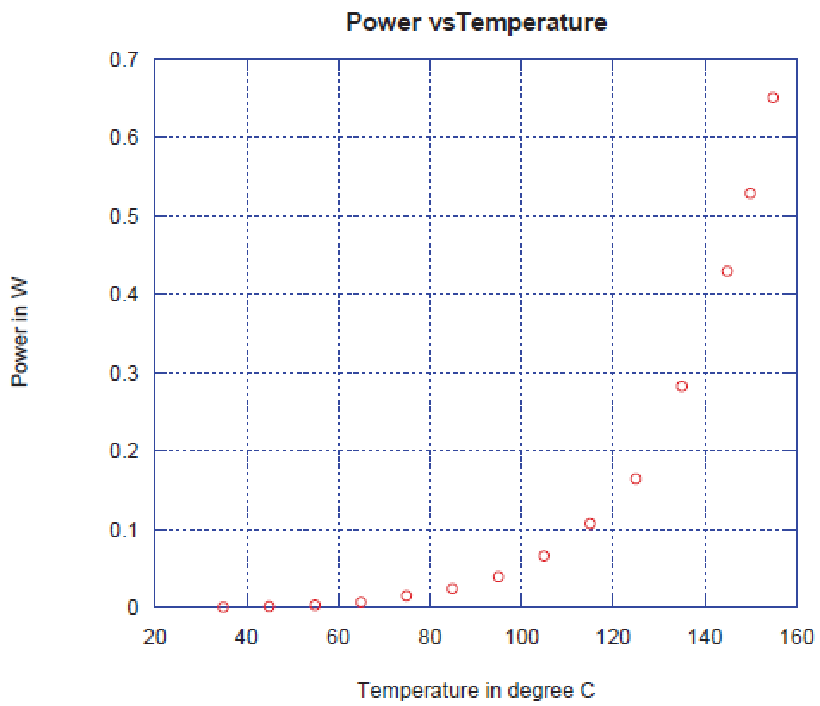

Figure 7.4: Power vs Temperature

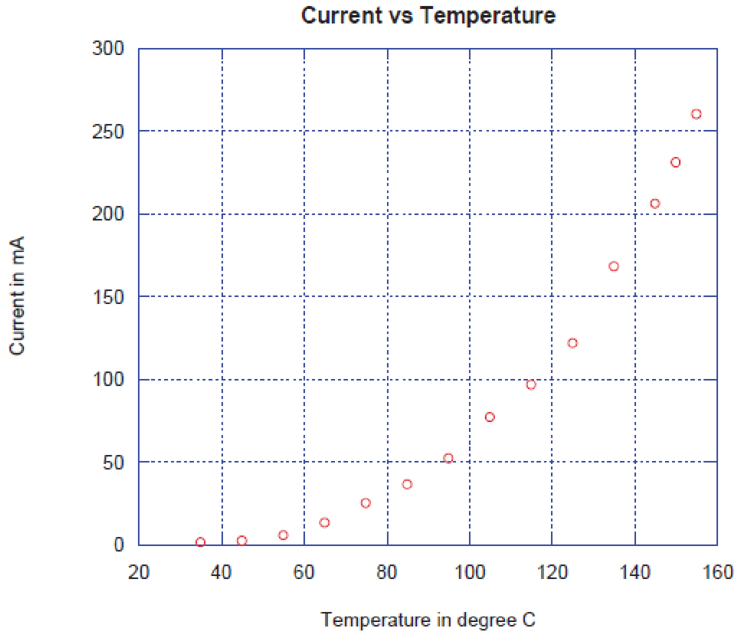

Figure 5.5: Current vs Temperature

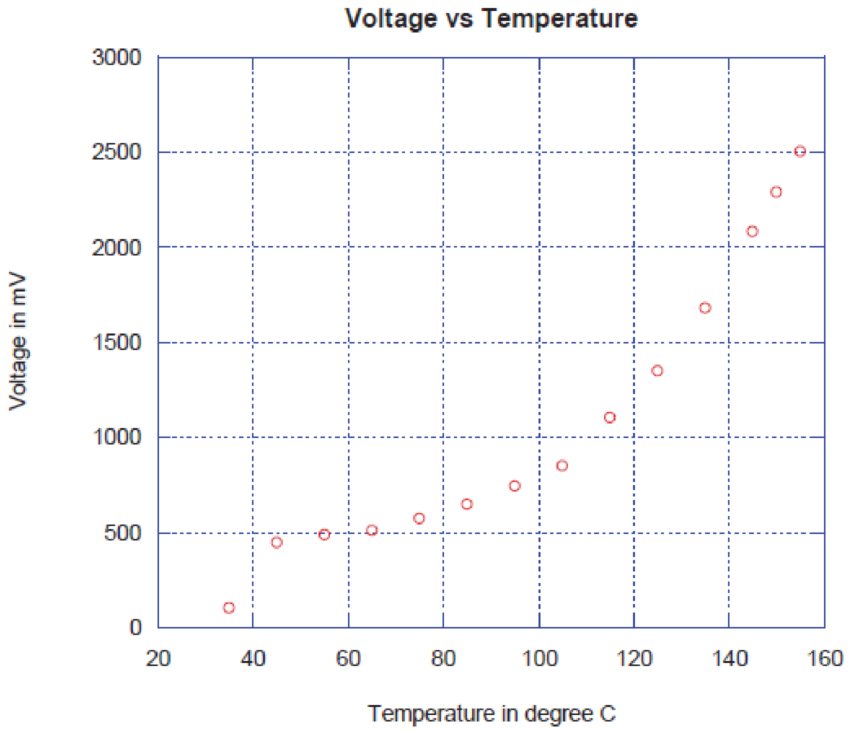

Figure 5.6: Voltage vs Temperature

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.

The basic concepts of power generation by thermoelectric generators and its relevant applications in the waste heat recovery systems. The study is useful in power generation by using Bismuth- Telluride TEG where availability of waste heat is high like engine exhaust, furnaces, heaters, stoves etc. This study shows that the power produced is directly proportional to the temperature of the hot surface. Maximum power output obtained was 650mW and further experiments are being conducted to improve the performance by using effective heat exchanger.

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