THERMOELECTRIC GENERATOR

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Abstract - *In today's environment we are more focused and interested in deploying sustainable and renewable energy that produce less carbon emission and eco-friendly energy. Energy users are continuously asking for instruments that can gives us required amount of energy for their domestic and other uses, at the time when power is unavailable as well as addition to their normal usage. The most prominent difficulties coming with these devices are there designs are complex, bulky and expensive. In addition to that energy sources for these type of renewable energy generators are not available in ready to use form. What we needed is to design a generator that will be low in cost, storable and easy to use that provides supplemental energy to the home or emergency backup electricity if there is power cut. We are believing to design a thermoelectric generator that can use waste heat energy produce by machinery works and other process that produce thermal energy. The major advantage of this generator is that the electricity produced is clean, safe and user friendly.*

Key Words: THERMOELECTRIC GENERATOR, ECO-FRIENDLY ENERGY, THERMOELECTRIC MODULE, VOLTAGE REGULATOR.

1. INTRODUCTION

The project is to design a low cost, storable, easy to use thermoelectric generator that will provide us supplemental electrical energy to the home and backup electricity if there is power cut. The generator that we are designing will utilises the waste heat produce in mechanical machine operation like silencers and combustors as input energy source. The TEGs answers the need for a sustainable, small, simple home energy source.

The design of the TEGs went through following main stages. Each stage was defined by the breakthroughs or changes in the method of heat transport.

In the first stage, heat is collected directly by thermoelectric module which converts heat into electrical energy by the phenomenon of Seebeck effect. This approach is simple and little effort of the part of the user.

The second stage is voltage regulation with the help of voltage regulator named LM78XX series voltage regulator to control the output voltage given by thermoelectric module.

The third stage is microcontroller and liquid crystal display part that is for automatic control and digital interface that helps to understand the working conditions of the TEG.

2. PROBLEM STATEMENT

The main challenge that comes to design a thermoelectric generator is the efficiency of the generator which is very low. Thermoelectric module works on seebeck effect which requires a minimal temperature difference between two sides named as hot panel and cold panel. If the temperature difference is maintained ideally the efficiency of the thermoelectric module improved and we get rated output voltage to serve this purpose we need to design a cooling system comprise of a heat sink and a fan which acts heat exhauster and helps in maintaining the temperature between the two sides of the thermoelectric module. After this stage we need to regulate the voltage as the output module is non uniform and contain ripples. For this purpose we used LM78xx series voltage regulator.

Further the task may be better with the aid of the use of microcontrollers for the better interfacing.

3. WORKING

A TEM is composed of many thermoelements like bismuth telluride in series electrical link for increasing operating voltage and also in parallel thermal connection to improve the thermal conductivity. Thermoelectric module convert heat energy to electrical energy on the basis of Seebeck effect when there is temperature difference occurs. The electrical equivalent circuit of thermoelectric generator is a voltage V and an internal resistance R, which is similar to a battery. Thermoelectric modules are placed directly on the top of surface and mounted uniformly over the available surface of the heat exchanger. The cold-side temperature of the modules is maintained by the coolant system.

3.1 THERMOELECTRIC MODULE

A thermoelectric module is used for both heating and cooling purposes. A TEM also used for power generation purpose where we need to apply a temperature difference across the module to generate a current.

It mainly contains n and p-type doped semiconductor materials which are connected thermally in parallel and electrically in series. They are mounted between two ceramic layers that keep the overall structure together mechanically. It insulate the individual elements from one another electrically and from external mounting surfaces. Most TEM comes in size of approximately 2.5-50 mm (0.1 to 2.0 inches) square and 2.5-5mm (0.1 to 0.2 inches) in height. Both of these types that is N-type and P-type Bismuth Telluride thermoelectric materials are used in a TEG. N-type material is highly doped so that it will have an excess of electrons and P-type material is doped so that it will have a deficiency of electrons. By varying temperature we can control the output current generate across the module.

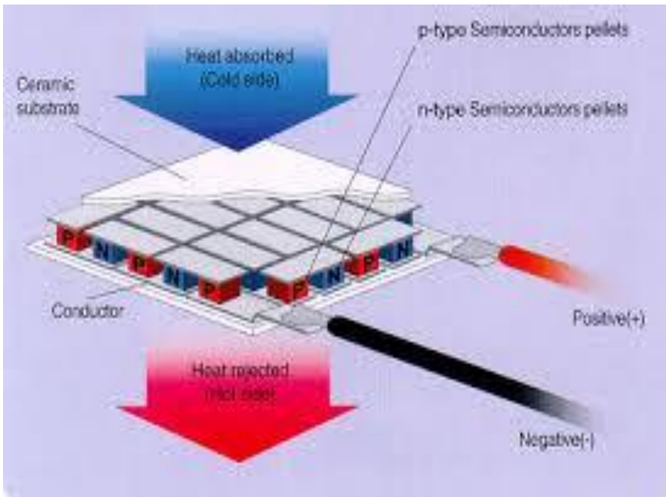

Fig -1: Thermoelectric Module

3.2 LM78XX SERIES VOLTAGE REGULATOR

A voltage regulator is use to generate a fixed output voltage that remains constant regardless of changes to its input voltage or load conditions.

A linear regulator employs controlled by a high gain differential amplifier. It compared the output voltage with precise set voltage and adjusts the pass device to maintain a constant output voltage.

A switching regulator is use for converting the dc voltage into a switched voltage applied to a power MOSFET or BJT switch. The output voltage is then feedback to the circuit for controlling the power switch on and off times so that the output voltage remains constant regardless of input voltage or load current changes.

The power dissipation of a voltage regulator is directly proportional to its output current for a given input and output voltage, which efficiencies can be 50% or even lower. Using the optimum components, a switching regulator can achieve efficiencies up to 90%. The linear regulator has much lower noise than a switching regulator with the same output voltage and current requirements. Typically, the switching regulator can drive higher current loads than a linear regulator.

Average ΔT(°C)	Maximum power generated (W) = V * I	Load resistance (Ω)	Load voltage(V)	Load current (amp)
20	0.232	1.45	0.58	0.4
26	0.436	2.47	1.04	0.42
35	1.156	3.96	2.14	0.54
44	1.996	5.19	3.22	0.62
55	2.563	5.15	3.61	0.71
68	4.057	5.75	4.83	0.84

Table 1: Observation Table

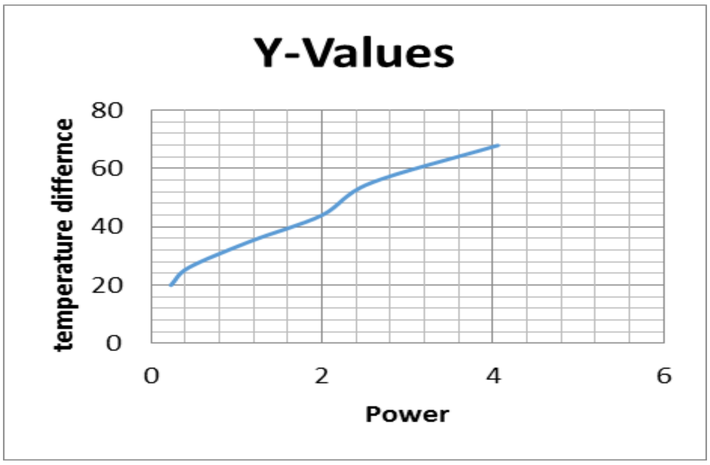

Fig-2: Performance Graph

4. ADVANTAGE

1. No moving part
2. Quiet operation
3. Long life
4. Low maintenance
5. Environmental friendly

5. APPLICATIONS

1. It can be used to charge mobile phones and tablets

2. It can be used to feed cooling system of heavy machinery

3. It can be used to light led bulbs

6. RESULTS

We observe the following results for a Bismuth Telluride thermoelectric device (TEC1-12706). The load resistance is variable in the experimental setup and the power generation and efficiency are both plotted versus the voltage produced. The maximum temperature difference we tested is being 68°C and it produced an output power of 4.057 watts. As we see efficiency of the generator is quite low because of their relatively low conversion efficiency. As for the convenience, we take the maximum temperature difference (68°C) which is a very modest value, higher temperature differences would result in higher efficiency. Generally thermoelectric devices requires temperature difference approximately up to 500°C to achieve an efficiency upto10%.

7. CONCLUSIONS

This project determines the performance of the thermoelectric generator under mismatch conditions such as the limited working temperature and the inconsistent temperature distributions among the modules in series connection.

The experimental data are presented to highlights the effect on the electrical performance when the modules are being operating in mismatch conditions, such as mechanical load and mismatch temperature. It can be concluded that a proper difference in temperature applied between two sides of module improves the electrical performance. The experimental results show that the power loss of the modules in series connection is significant, 11% less than the theoretical maximum power, due to the temperature mismatch condition. This situation can be improved from thermal insulation on the modules and the power loss due to the inconsistent temperature distributions reduces to 2.3% at the same working condition. It is suggested that thermal insulation method trades a new effective way to regulate the inconsistent electrical characteristics of the modules under mismatch conditions and improve the performance of TEG system under higher engine speeds.

REFERENCES

[1] R. Ahiska, S. Dislitas Computer controlled test system for measuring the parameters of the real thermoelectric module
[2] C. Yu, K.T. Chau Thermoelectric automotive waste heat energy recovery using maximum power point tracking
[3] Yang jihui, R. Stabler Francis Automotive applications of thermoelectric material
[4]D.T. Crane, J.W. Lagrandeur Progress report on BSST Led US Department of Energy automotive waste heat recovery program
[5]Hongliang Lu, Ting Wu Experiment on thermal uniformity and pressure drop of exhaust heat exchanger for automotive thermoelectric generator