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ENERGY HARVESTING USING PELTIER CELL THROUGH COLD AND HEAT JUNCTIONS

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***Abstract*— This paper is based on the idea to harvest the energy wasted in the form of heat in various applications. This is done by converting the wasted heat energy to electrical energy with the help of a Peltier Element which converts the heat to electricity based on the See beck Effect. The electric potential so generated is boosted using a Sepic Converter thus increasing the voltage to be in par with the application. There is a safety measure to prevent the Peltier Element from damage due to exposure to high temperature with the help of a Temperature Sensor.**

***Keywords* - See beck Effect; Peltier Element; Sepic Converter; Temperature Sensor; PIC Microcontroller.**

I. INTRODUCTION

In the present century, the energy crisis has drawn hue and cry of even the developed nations. It has become a common notion around the globe to switch over to renewable resources in more ways. The fossil fuels are in a verge of exhaustion so their life is only valid for a few decades. The energy demand has risen steeply over the few years due to the drastic transformation of the lifestyle. There are various technologies to get energy from sun, wind, molten magma and the list goes on. To trap Wasted heat and convert to electricity is one way which can be used to charge batteries, run motors, light appliances etc. The waste heat can be tapped from the automobile engines heat dissipated from industrial equipments, human body parts, hot combustion products. This is converted to electric potential using the Thermo Electric Generator or Peltier Element. The energy produced is not compatible with that of the application so a converter is used to boost the voltage and charge a battery which can be used for various appliances.

II. HEAT- A FORM OF ENERGY:

According to First Law of Thermodynamics, Heat is a form of energy which can only be converted to other forms of energy. Thus there is only a reconversion of energy. A Thermocouple is formed when there is a junction formed due to the combination of different metals at the hot and cold end. Thermocouple when subjected to temperature difference at the hot and cold junction leads to the production of an emf. This is due to the fact that heat flows from hot body to cold body. The ways of heat transfer can be Conduction, Convection, and Radiation. The laws of Thermodynamics are applicable to all the heat bodies. Heat is measured in Joules. Examples of heat producing devices are Heat pump, Rankine engine. These devices emit heat during their operation. There occurs a temperature rise due to the heat exhaust.

A. SEE BECK EFFECT:

The Thermoelectric Energy is obtained by the conversion of the generated heat energy into electrical energy. It can be explained by the principle of See beck effect, which can be stated as, “When the two ends of the conductor are subjected to different temperatures, the electrons at the hot junction diffuse into the cold junction.” [2]. The electrons at hot junction are at higher thermal velocities than the electrons on the other end. This is due to more agitation of the electrons due to high temperature. This defines that the thermal electrons move from the junction in the hot region to the junction in the cold region. Thus the emf produced in the thermoelectric cell is proportional to the corresponding temperature difference. The potential difference can be obtained as $V = \alpha\Delta T$, where, temperature difference $\Delta T = Th - Tc$ and α is the See beck coefficient expressed in μV. The sign of α is positive if emf tends to drive an electric current through the wire from hot to cold junction and is negative vice versa [2].

B. THERMO ELECTRIC COOLER:

Thermo Electric Cooler (TEC) also known as Peltier element was discovered by Jean Charles Athanase Peltier, a French physicist.TEC works on reverse See beck Effect. Thus when there is emf applied across a Thermocouple, there is a cooling effect observed. TEC and TEG can also be used be used to generate electricity by See beck Effect. TEC is mainly used for a low temperature range. It is also cost effective compared to TEG. TEG is used when there is a high temperature difference and the voltage output is much more than that of TEC. But TEC has thick wire to assist more Ampere. In the construction of TEC there is a layer of n-type and p-type semiconductor to provide different electron density, forming a junction. The semiconductors are placed thermally parallel to each other and in series electrically. It is connected by a thermally conducting plate on either side. The output voltage produced is directly proportional to the number of TEC's used and also its geometry. Normally Bismuth telluride, Lead telluride, Silicon germanium are used. Bismuth telluride is the most common. The TEC have the cell detail on the hot side. Efficiency is a feature of the semiconductor used. The heat transport depends on See beck effect, Peltier effect, Thomson effect. There is a requirement of high or doping in the p and n type semiconductor.

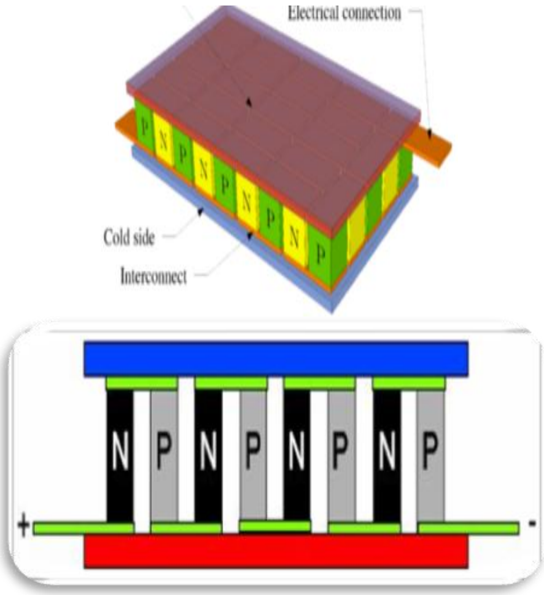

Fig: Peltier Element showing hot and cold side

The model designed here consists of a Peltier module with the other supporting devices. The Peltier module is exposed to a temperature difference using a heat sink. The output voltage is given to the Charging circuit with an inbuilt Regulator. This circuit charges a Lead acid Battery. From Battery the voltage is boosted by a Sepic Converter. To drive the converter, MOSFET Driver Circuit is used. PIC Controller is programmed for controlling the following operations. First, it helps to design the duty cycle of the PWM Pulses to the MOSFET through the driver circuit. Monitoring of the Temperature sensor and switching the exhaust Fan is also done. The Temperature Sensor monitors the temperature of the Peltier module and when the temperature rises beyond the threshold value the cooling of the TEC is done.

C. SEPIC CONVERTER:

Sepic Converter is a dc-dc converter. Sepic means Single Ended Primary Inductor Converter. The output of the converter can be either greater, less or equal. This is done with the help of the duty cycle of the PWM Pulses. When compared with a Buck-Boost Converter, the main advantage is the output of this converter is non-inverted. The energy exchange is between the Inductor and the Capacitor in the circuit for conversion of voltages. MOSFET offers a high impedance and lower voltage drop than BJT. There are two modes here: continuous and discontinuous mode. The coupling energy of the capacitor from input to output allows the device to control better during a short circuit. It is very useful for non-isolated battery circuits. The voltage drop and the switching speed determine the reliability and efficiency. Thus fast switching devices are preferred. The capacitance and internal resistance also decides the efficiency and ripple of the converter. The values of L and C can be calculated using the formulae.

D. L & C CALCULATIONS IN SEPIC BOOSTER CIRCUIT:

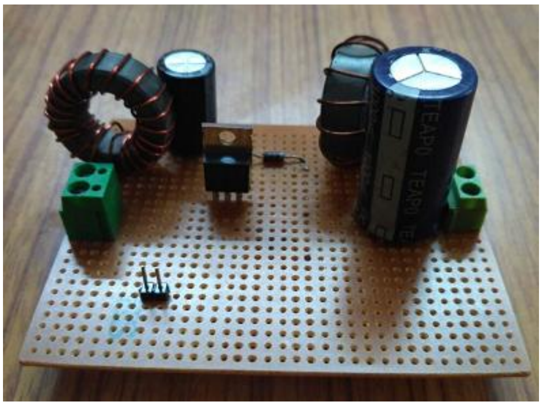

Fig. SEPIC Converter Circuit

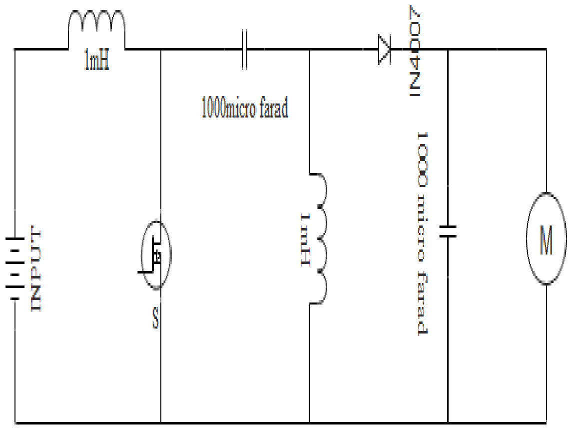

Fig. Equivalent Circuit shown connected to a motor load

For assuming efficiency, n=0.9

Duty cycle,D=1-((Vin*n)/Vout)

Inductor ripple current,

di =0.2*I*(Vout/Vin)

Inductance,

L1=((Vin*(Vout-Vin))/di*Fs*Vout)

L2=(Vin*D)/(di*Fs)

Voltage ripple,

dv=(I/(1-D))+(di/2)

dv=0.5

Capacitance,

C1=(I*D)/(Fs*dv)

C2=I/(Fs*dv)

Resistance, R=Vout/I

E. PELTIER ELEMENT:

The Peltier cell is made of a thermocouple with Bismuth telluride generally. When the inner side of the cell is viewed the p-type and n-type semiconductor design can be observed. The cell can be exposed to heat with a proper design of heat sink. The temperature difference required by this cell is around 33^{o} Cto 72^{o}C. The temperature difference produces a nominal voltage of 4 to 6 V according to the specification mentioned in the cell. By connecting array of cells in series, the output can be increased. Thus, the potential developed is directly proportional to the number of cells used. Generally, from the TEC specification the output from the cell can be known. TEC 12706 means the current rating is 6 A and there are 127 highly doped p-n couples in the cell.

III. WORKING:

The Peltier module is exposed to a temperature difference by heating the hot side. The voltage produced is then given to battery. The Lead acid battery is charged to 12 V. The voltage is boosted to around 80V according to specific application. The Mosfet driver circuit is driven by the PWM Pulses of required duty cycle from the PIC Controller. A Step down transformer is used as supply for the driver circuit. The Temperature sensor senses the temperature and gives the data to the PIC. The PIC with a driver circuit for the cooling fan turns it ON when the temperature rises beyond the set value. The Sepic converter is used to charge the mobile or drive a dc motor accordingly.

IV. RESULT:

In the experiment conducted above, a voltage of 4V is produced from the Peltier Cell. This is boosted up to 48V using the Sepic Converter so as to drive the dc motor which is the application used here. The temperature difference is 70^{o}C.

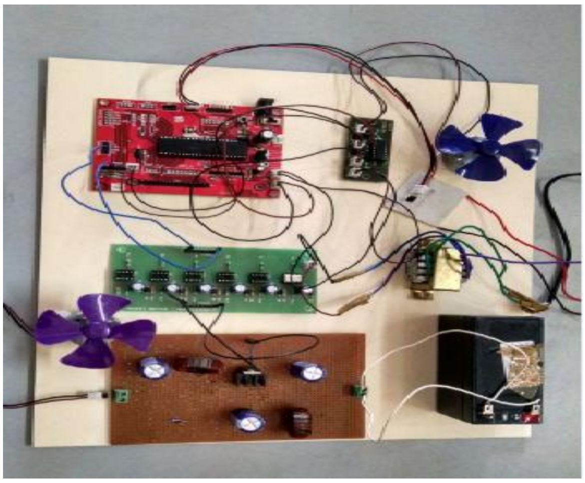

Fig: Prototype Model

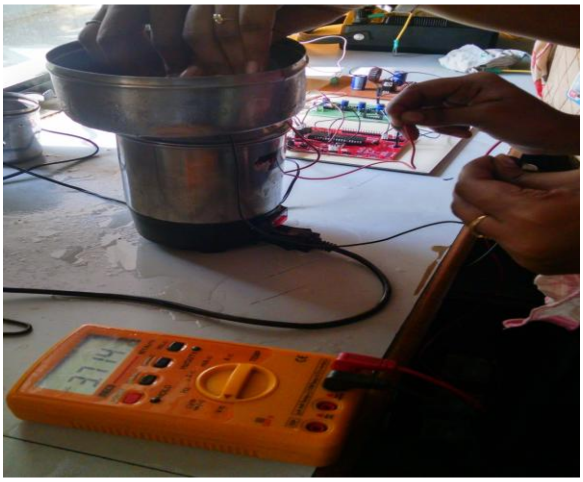

Fig: Output from TEC

V. CONCLUSION

There is an increase in the demand for energy in our day to day activities, from simple to complex applications. Due to scarcity of resources , we need to conserve the energy. This project aims to conserve the electrical energy to some extent by trapping the waste heat from the heat source in automobile applications. This waste heat can also be trapped from the home appliances like refridgerator where there is a hot & cold junction to produce energy. So, by the efficient usage for waste heat energy from the appliances, the useful electrical energy could be generated to support such appliances.

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