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Akshatha S K, Prasnna kumar M

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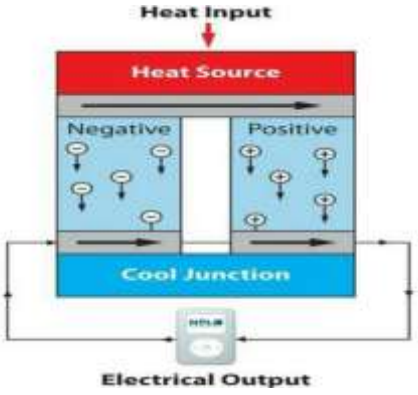
Peltier sensor converts thermal energy into electrical energy. This energy can be used for charging the battery without the main supply. This paper shows that heat harvested from different heat sources generate different amount of voltages and overall power. Experimentations also showed that using different ways to extract heat from the other side of the module made output voltage to vary accordingly.

Keywords—Seebeck effect; Peltier effect; Thermoelectric; Energy Harvesting;

I. INTRODUCTION:

Due to increase in the carbon dioxide level and other harmful gases specially which are contributing in increase in pollution and global warming, our automobile industries are one of the easy and clear target therefore many researches has been undertaken in this field. Globally, it is estimated that about 1/3 of the total energy is utilized while remaining is rejected as waste heat. The maximum efficiency of an engine is around 25% which means that 75 % of the energy left is wasted in the form of heat from parasitic losses and friction which causes 30% waste in the engine coolant and 40% in the form of gases in exhaust. TEG is a solid stated device which works on the principle of 'Seebeck effect'.They are found in solar energy systems like solar panels, solar hot water system, biomass power applications, energy power plants and solar pond systems. Installing a TEG is easy and very beneficial as it has some advantages like small in size, it has no vibrations, makes less or no noise while operating, it generally requires less or no maintenance. And major advantage is that it is using free thermal energy and converting into useful electrical energy. Two metallic strips, made of different metals and joined at the ends to form a loop. If the junctions are kept at different temperatures then there is an electric current in the loop and the emf developed is called the SEEBECK emf or thermo emf and the current can be used to power a load.Thermoelectric materials are packed between the hot-side and the cold-side heat exchangers. The thermoelectric materials are made up of p-type and n-type semiconductors, while the heat exchangers are metal plates with high thermal conductivity.The temperature difference between the two surfaces of the thermoelectric module(s) generates electricity using the Seebeck Effect.



When TEG is exposed to heat, the charge carriers of the semiconductors within the generator diffuse from the hot-side heat exchanger to the cold-side exchanger. The build-up of charge carriers results in a net charge, producing an electrostatic potential while the heat transfer drives a current.With temperatures of 700 °C (≈1300 °F) or more, the temperature difference between the hot side and the cold side is several hundred degrees. This temperature difference is capable of generating 500-750 W of electricity.

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1.2. Types of TEG: Thermoelectric generator materials and their temperatures range is as follows [3]. There are number of materials known till date but few are identified as thermoelectric materials.

Sl no.	TEG Materials	Temp range
1	Material based on Si-Ge alloys	Up to1300 K
2	Materials based on alloys of Lead (Pb)	Up to 850K
3	Alloys based on Bismuth (Bi) in combinations with Antimony(An), Tellurium (Te) or Selenium (Se)	Up to 450K

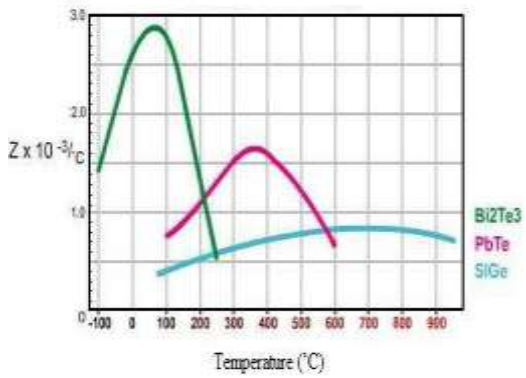


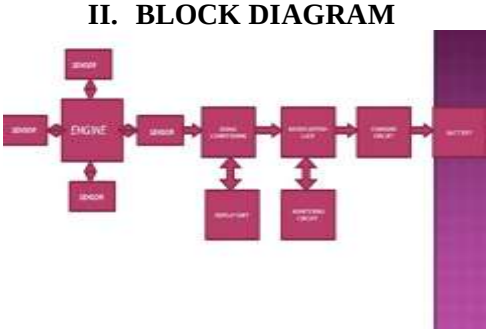
Fig: Performance of Thermoelectric Materials at various temperatures

The figure of merit Z describes material performance. It depends on the thermoelectric material properties.

$$z=\frac{\alpha^2\sigma}{k}$$

where, α =Seebeck coefficient, σ = electrical conductivity, k = thermal conductivity.

II. BLOCK DIAGRAM



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2.1 TEG: A thermoelectric generator is a semiconductor based electronic component that converts heat into electricity using a phenomenon called Seebeck effect. Three thermoelectric generators connected in series are used in the experimental setup.

The Specification of the Peltier module

1. Model number: TEC1-12706
2. Operating Voltage: 12V
3. Maximum Voltage- Umax (V) : 15.4V
4. Maximum Current- Imax (A) : 6A
5. Maximum Power : 92 W
6. Maximum Temperature : 138°C

2.2 Heat source: The copper plate with dimensions 200mm x100mm x 5mm acts as a heat source, which is fitted to Exhaust pipe near the Engine. The hot junctions of the TEGs are connected to the copper plate.

2.3 Booster circuit:

The DC-DC Module is based on IC XL6009E1 which is a high-performance step-up switching current (BOOST) module.The module uses the second generation of high-frequency switching technology core chip that offers superior performance over the first generation technology.

The specification of buck booster are:

1. Input Range: 3V ~ 32V
2. Output Range: 5V ~ 35V
3. Input Current: 4A (maximum), load 18mA
4. Conversion efficiency:<94%
5. Switching frequency: 400KHz
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PT100 increases its resistance as heat is applied. The temperature vs. resistance characteristic is described in pt100 resistance table.

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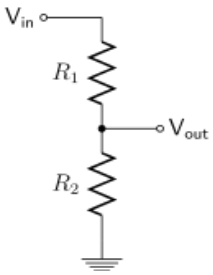

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The load attached across the circuit have- (a) LED Indicator (b) Electronic Flasher (c) Piezoelectric Buzzer (d)Mobile charger (e) Parking Horn.

III. EXPERIMENTATION:

When the engine started, gradually the temperature of the engineer rises. The hot junction gets heated up and the heat transfer rate increases across the TEG,and starts generating the voltage. The voltage generated by the Peltier sensor is small in magnitude.Therefore, the IC XL6009E1 buck booster is used to Amplify the voltage. The PT100 RTD temperature sensor is used the measure the temperature using Arduino. The test was conducted to measure the temperature at different speed and also the voltage generated by the Peltier Sensor.The charging circuit will charge the 12V battery to which various loads are connected and tests were conducted.

IV. RESULTS

The experiment was conducted by running the engine ate various speed and the temperature and voltage generated is tabulated.

RPM	Temperature	Generated Voltage	Boosted Voltage
1000	53.2	7.1	13.2
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V. DISCUSSION:

The TEG used in this work is operated between the temperature range 40˚C to 120˚C. The exhaust pipe near the engine reaches to 130˚C. At 1000 RPM, the temperature reaches 53.2˚C producing boosted voltage of 13.2V Similarly when engine runs at 2000 RPM, heat source get heated up to 61.3˚C generating voltage of 13.6V. When engine run at 3000rpm heat source is heated up to 65.4˚C generating 14.2V volts.

VI. CONCLUSION

TEG is a promising technology for recovering waste heat of the vehicle. Performance of a TEG can be varied according to the change in vehicle speed, engine rpm and installation position.when thermoelectric generators are connected in series, the generated power either directly used to run some auxiliary devices of an automobile or may be stored in the battery and later use.

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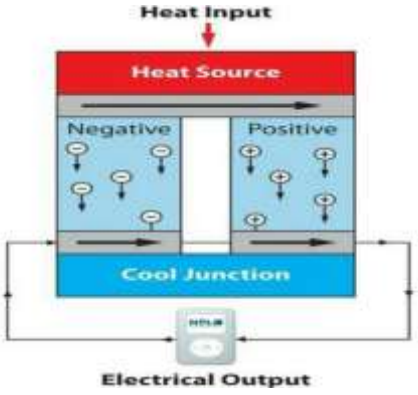

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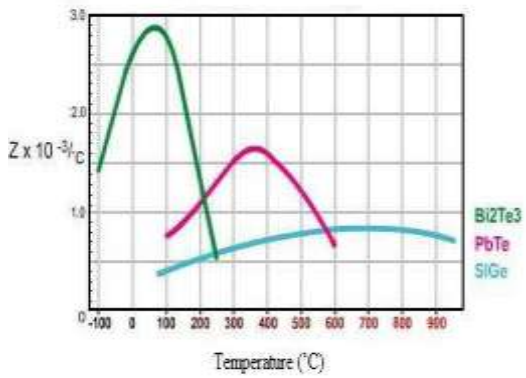

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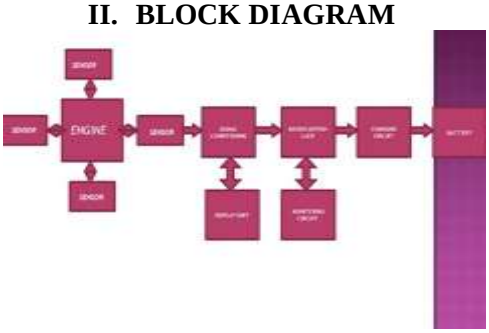

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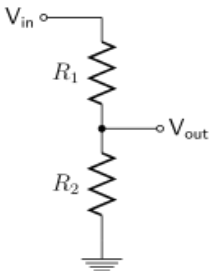

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