Generation of Electric Power Through Waste Heat Using Thermoelectric Effect

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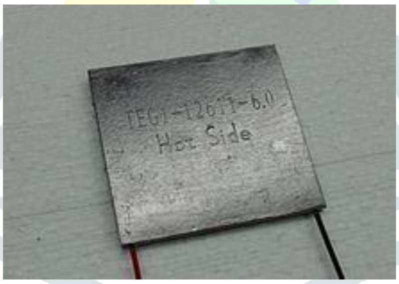
Abstract: Today, demand of electrical power is getting more. Because of limitations of conventional sources of energy, it is required to generate electricity by alternate way. One of the solutions of this issue is to get electricity using thermo electrical effect. Many scientists of world applied their research on Thermo electric principle. By this project, we can utilize the waste heat at free of cost which are exhausted in atmosphere. Thermo electric effect in which Cold and Hot medium are passed on different side of thermoelectric plate. Due to temperature difference electric power is generated. TEG has no mechanical moving part, hence it is less costly.

1. INTRODUCTION

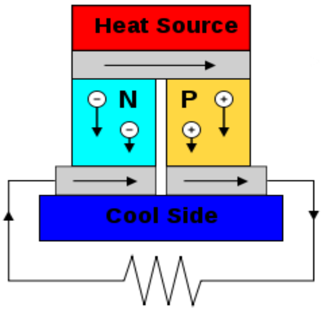
HISTORY

The thermoelectric effect is the immediate transformation to electrical voltage of temperature variations and vice versa. When there is a distinct temperature on each side, a thermoelectric device generates voltage. Conversely, it produces a temperature difference when a voltage is applied to it. A temperature gradient applied at the atomic scale leads the material's charging carriers to diffuse from the hot to the cold side. This impact can be used for generating electricity, measuring temperature, or changing object temperature. Due to the polarity of the applied voltage determining the direction of heating and cooling, thermoelectric systems can be used as temperature controllers. Three individually recognized impacts are covered by the word "thermoelectric effect": Seebeck effect, Peltier effect, and Thomson effect. The effects of Seebeck and Peltier are different manifestations of the same physical process; textbooks can refer to this process as the effect of Peltier – Seebeck (the separation derives from the independent findings of French physicist Jean Charles Athanase Peltier and Baltic German physicist Thomas Johann Seebeck). The Thomson effect is a Peltier–Seebeck model expansion and is credited to Lord Kelvin. Joule heating is related to the heat generated when a current is passed through a resistive material, although generally it is not called a thermoelectric effect. The Peltier-Seebeck and Tomson effects are thermodynamically reversible, whereas Joule heating in not.



SEEBECK EFFECT

The Seebeck effect is directly converting heat into electricity at the junctions of various wire kinds. It is named after the Baltic German physicist Thomas Johann Seebeck, who found in 1821 that a compass needle would be deflected by a closed loop created by two distinct metals joined in two locations, with a difference in temperature between the joints. This was because the concentrations of electron energy changed differently in each metal and a potential difference between the junctions generated an electrical current and therefore a magnetic field around the cables. Seebeck did not acknowledge the involvement of an electric current, so he called the "thermomagnetic effect" phenomenon. Hans Christian, a Danish physicist, corrected the oversight and coined the term "thermoelectricity." The Seebeck effect is a classic instance of an electromotive force (emf) and leads in the same manner as any other emf to measurable currents or voltages. Electromotive forces modify Ohm's law by generating currents even in the absence of voltage differences (or vice versa).
The coefficients of Seebeck usually differ as a function of temperature and are heavily dependent on the conductor's composition. The Seebeck coefficient may vary from −100 μV / K to + 1,000 μV / K for normal metals at room temperature (see Seebeck coefficient article for more data). A metal of unknown composition can be categorized by its thermoelectric effect if a metal sample of known composition is kept at a steady temperature and is retained in touch with the unknown sample locally heated to the temperature of the sample. It is used to define metal alloys commercially. Series of thermocouples form a thermopile. Thermoelectric generators are used to generate electrical power from thermal differential energy. A thermoelectric circuit made up of various Seebeck coefficient components (p-doped and n-doped semiconductors), configured as a thermoelectric generator. If the load resistor at the bottom is substituted by a voltmeter, the circuit will function as a thermocouple for temperature sensing.



2. LITRETURE REVIEW

THERMO-ELECTRIC GENERATORS (TEG)

Power generation methods such as wood burning, gasoline, diesel, coal, are continually depleting with nature, thus exceeding the consumption of energy by consumer demand. Global warming is the rise in and predicted continuation of the Earth's average measured temperature close ground air and oceans since the mid-20th century. Temperature of the global surface increased 0.74 ± 0.18 ° C (1.33 ± 0.32 ° F).

Thomas Jon Seebeck (1934) created that between two dissimilar conductor’s temperature generates voltage and current. At the core of the thermoelectric generator impact is the fact that a variation in temperature in a conductive material outcome in heat flow from side to side. A thermoelectric module is a circuit comprising directly heat-generating thermoelectric materials. A thermoelectric module comprises of two dissimilar thermoelectric components that come together at their ends: a n-type (negatively charged) ; and a p-type (strongly charged) semiconductor. If there is a temperature distinction between the two metals, a direct electrical current will flow in the circuit. The current magnitude generally has a proportional relation to the difference in temperature. (The greater the difference in temperature, the greater the current.)

Thermoelectric modules in power generation operate under very tough mechanical and thermal circumstances in implementation. Because they operate in very high temperature gradient, the modules are subject to large thermally induced stresses and strains for long periods of time. They also are subject to mechanical fatigue caused by large number of thermal cycles. It is therefore necessary to select the junctions and materials in order to survive these tough mechanical and thermal conditions. The module must also be intended in such a way that the two thermoelectric materials are parallel thermally, but in series electrically. The efficiency of thermoelectric system is greatly affected by its geometrical design. A thermoelectric system produces energy by taking heat from a source such as a hot exhaust flue using thermoelectric modules. To do this, a huge temperature gradient is needed by the system, which is not simple in real-world application. Air or water must cool the cold side. Heat exchangers are used for supplying this heating and cooling on both sides of the modules.

The design of a reliable TEG system that works at high temperatures creates many difficulties. To achieve high system efficiency, comprehensive engineering design is required to balance the heat flow through the modules and maximize the temperature gradient across the modules. To do this, one of the most significant elements of TEG engineering is the design of heat exchanger systems in the scheme. Moreover, owing to the interfaces between components at several locations, the system needs minimizing heat losses. Another difficult constraint is to avoid big drops of pressure between sources of heating and cooling. The TEG generates AC power after passing the DC power from the TE modules through an inverter, which in turn needs an integrated power electronics system to supply it to the client.

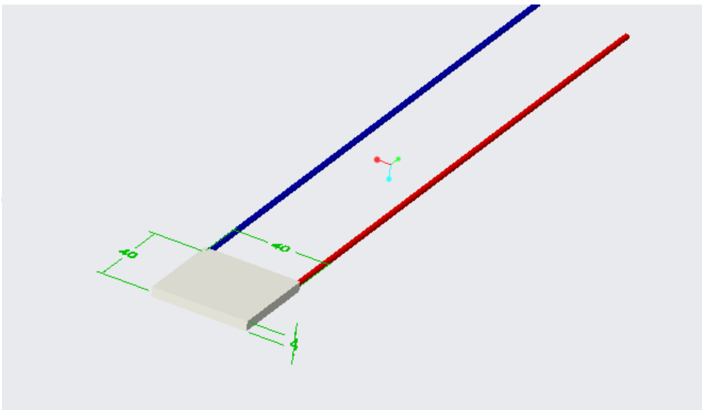
Shrutika Karpe, International Journal of Current Engineering and Technology showed that, in recent years, global warming and the limitations in use of energy resources increase environmental issues of emissions. Also, in industry, most of the expenses are due to energy (both electrical and thermal), labor 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 of the energy conversion systems. Even though output of TEGs is low with available techniques, feasible electricity generation is possible due to waste heat emitted from the automobile (internal combustion engine operation).

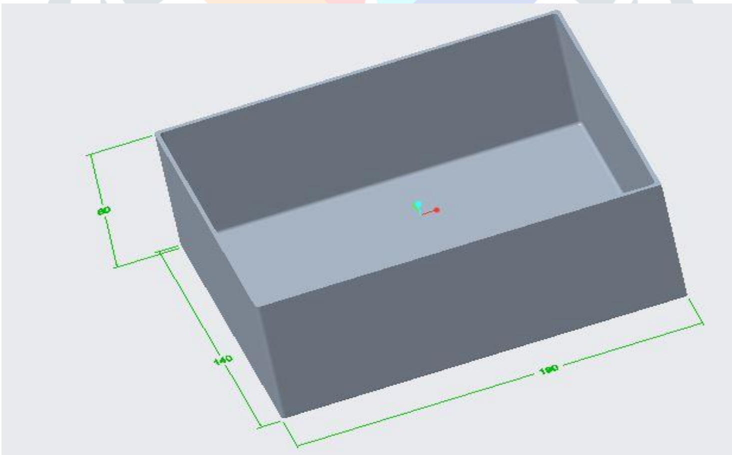
Priscilla A Stecanella & Co-authors suggested that, generating machines of electricity, using combustion engines and generate a great amount of residual thermal energy from the exhaust gases. This residual thermal energy can be converted into usable electricity using thermoelectric generator (TEG), which are manufactured cells with semiconductor materials employing the Seebeck effect. When recovering the waste heat in the exhaust ducts using TEG, increases the efficiency of electrical machines, because the same amount of fuel input generates more power or less intake of fuel, has the same amount the generated electric energy and thus less air pollution (as there will be less burning of fossil fuels) makes the system more sustainable. The purpose of this paper is present an electric generation plant using thermoelectric generator (TEG), which recover the thermal energy dissipated by combustion gases of an electric generator. To improve the efficiency of generation is carried out the control and supervision of the temperature on the cold side of the TEG. The Supervisory System is responsible for data acquisition and generation of graphs and reports.

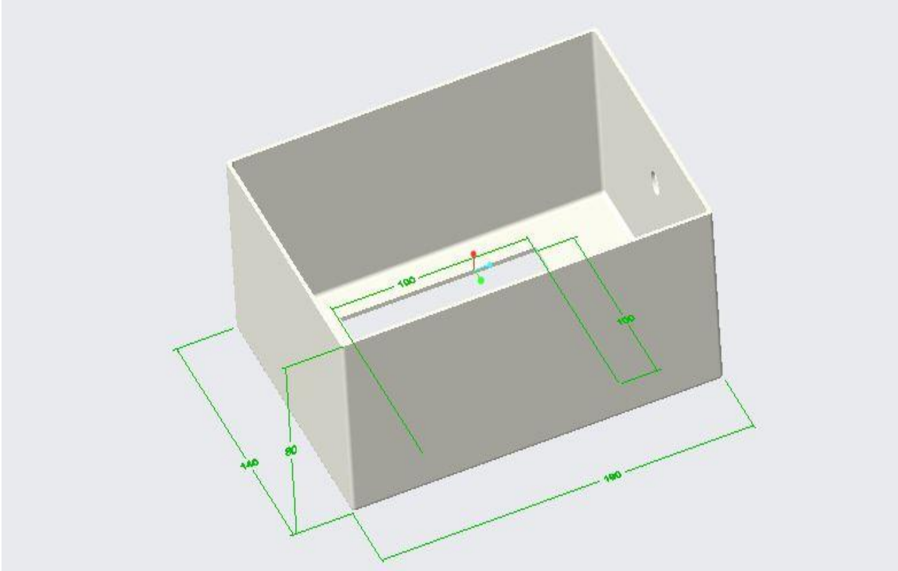
P Kardasz discussed the thermoelectric effects and the solutions of converting the waste heat into electricity were shown. The application and operation of thermoelectric for heat recovery from cars, the cogeneration of heat for home and in wristwatches were presented. An analysis of the possibilities of using Peltier cells in municipal and long-distance transport was conducted. The aim of the study was to evaluate the possibility of reducing fuel costs by obtaining electricity from the Peltier cells instead of the alternator. On their basis was possible to determine the amount of recovered energy thanks to their use. On the basis of calculations, it was concluded that at the current price of unit cell, the use of this solution is not fully economically justifiable. However, there are possible solutions that could increase the efficiency of the cell. The advantages of using cells are reducing the vehicle engine wear and emission of harmful substances into the environment. It was found that most justifiable is the mounting of cells in vehicles equipped with multiple electrical receivers with low efficiency of the engine. It was indicated that more and more new thermoelectric materials that provide efficient and cheap energy harvesting on a large scale are looking for.

3. DESIGN

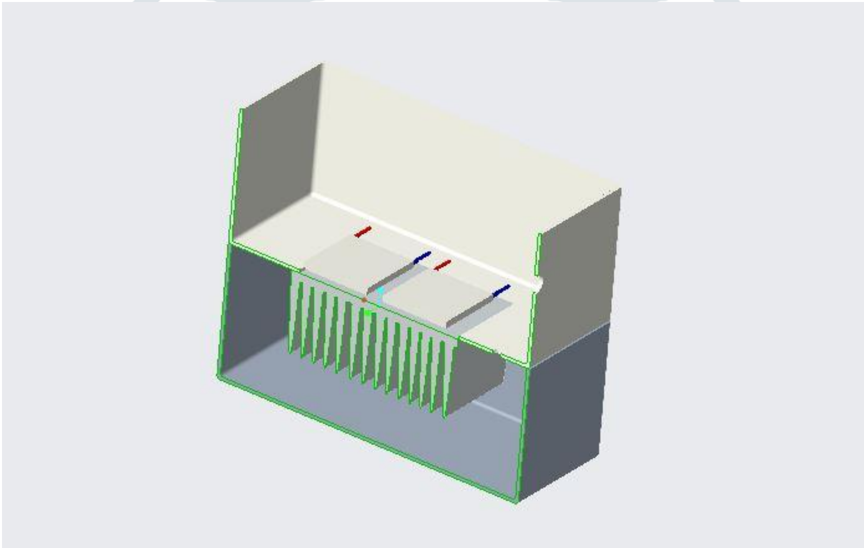
PARTS

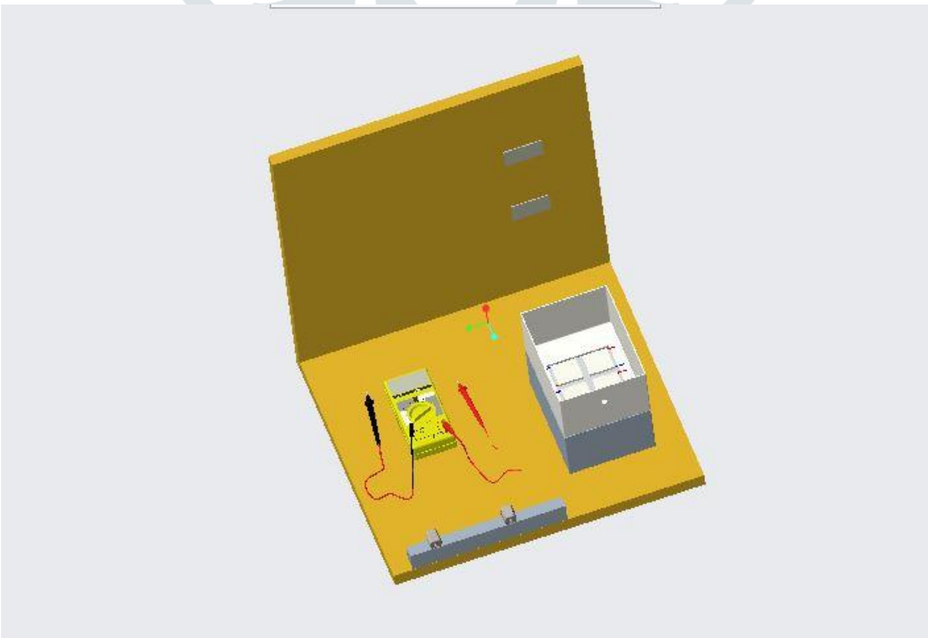






ASSEMBLY





4. PART LIST

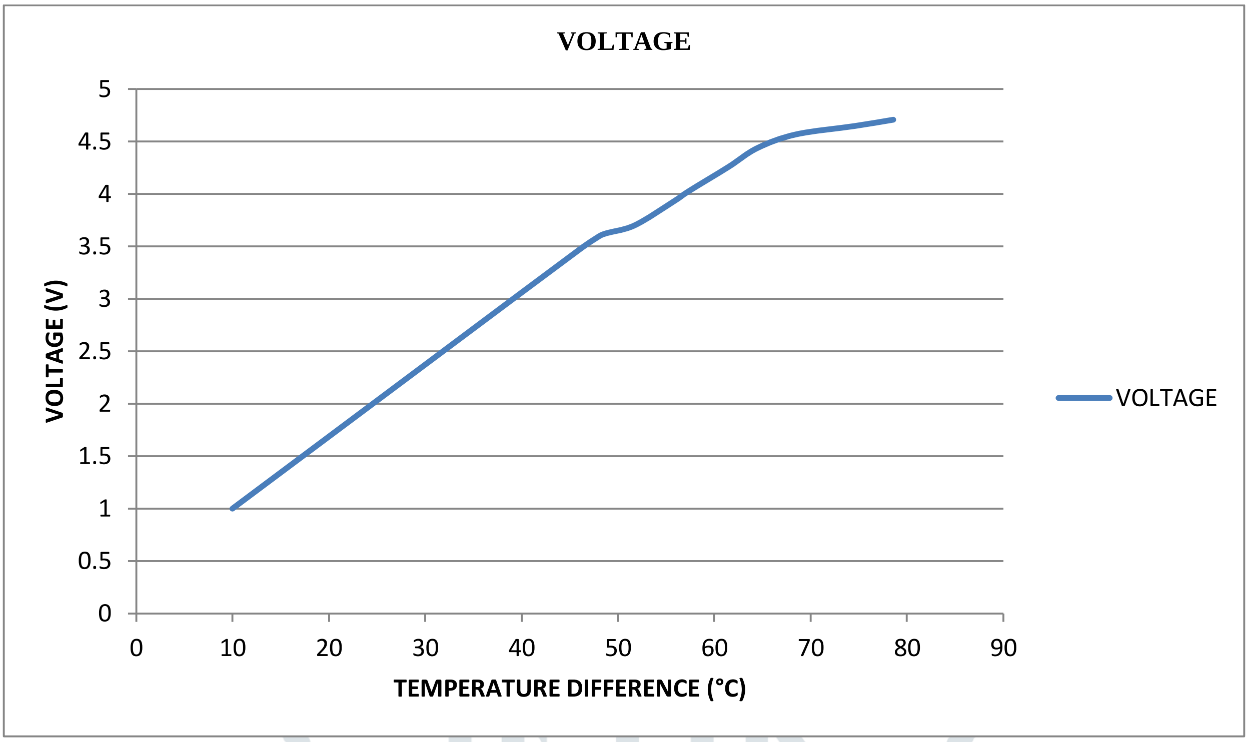
Sr. No.	Part Name	Qty.	Material
1	Thermo electric plate	4	Ceramic material Al_2O_3
2	Heat sink	2	Al
3	Multi meter	1	Plastic
4	Container	2	Plastic
5	Nut, Screws & Bolts	10	M.S.
6	Clamp	4	Plastic
7	Temperature Sensor	2	Plastic
8	Thermal Paste	1	Grey Thermal Grease is ISOL 6
9	DC Motor	1	Metal
10	Wooden Base	2	Wood
11	Banner	1	Plastic

5. RESULT ANALYSIS

OBSERVATION TABLE

SR. NO.	TIME (min)	HOT (°C) TEMPERATURE	COLD (°C) TEMPERATURE	TEMPERATURE DIFFERENCE (°C)	VOLTAGE
1	1	79.6	1	78.6	4.71
2	2	75.6	1	74.6	4.65
3	3	70	1.5	68.5	4.57
4	4	66.5	2	64.5	4.44
5	5	63.5	2	61.5	4.26
6	6	59.9	2.5	57.4	4.03
7	7	57.8	3	55.8	3.93
8	8	54.9	3.5	51.7	3.7
9	9	52.3	4	48.3	3.61
10	10	50	4	46	3.47
11	11	48	38	10	1

GRAPH



From observation table we have drawn graph between temperature difference (x- axis) and generated voltage (y- axis). From above graph, we have observed that when temperature difference between hot side (hot water) and cold side (chilled water) is decreases then generated voltage is also decreases.

During over experiment we got maximum voltage 4.71 at 79.6°C. We have used four plates in series connection, so each plate generates approximately 1.2 v electricity. Around 10°C temperature difference, 1 v electricity is being generated. This TEG is generating electricity at free of cost with less initial investment. If we want to use this TEG in industry, then it is obvious that more number of plates are required to be connected in series.

6. ADVANTAGES

1) Compact design, so it required less space.
2) No moving parts, so less costly. Working medium should be any – liquid, gas, solid, etc.
3) Waste heat is used as source of energy, so free of cost.
4) Because of more waste heat energy is released in atmosphere without utilization, source of heat energy is easily available.
5) This generator is used anywhere in the world where waste heat is source.

7. LIMITATIONS

a) High generator output resistance.
b) Low thermal conductivity.
c) Cold-side heat removal with air.
d) Low efficiency and relatively high cost, practical problems exist in using thermoelectric devices in certain types of applications resulting from a relatively
e) High electrical output resistance.

8. APPLICATIONS

A. Using thermoelectric generators on gas pipelines is common application. For example, for cathodic protection, radio communication, and other telemetry. Gas pipelines are preferred to other energy sources for power consumption of up to 5 kW thermal generators. Gentherm Global Power Technologies (formerly Global Thermoelectric), (Calgary, Canada) and TELGEN (Russia) are the producers of gas pipeline engines.

B. Thermoelectric generators are mainly used for unmanned locations as remote and off-grid power generators. In circumstances such as not having moving components (thus nearly maintenance-free), working day and night, performing under all weather conditions, they are the most reliable power generator and can operate without battery backup. Although Solar Photovoltaic systems are also deployed in remote locations, Solar PV may not be an appropriate solution for low solar radiation, i.e. regions at greater latitudes with snow or no sunshine, regions with lots of cloud or tree canopy cover, dusty deserts, woodlands, etc.

C. Gentherm Global Power Technologies (GPT) formerly known as Global Thermoelectric (Canada) has Hybrid Solar-TEG solutions where the Thermoelectric Generator backs up the Solar-PV, such that if the Solar panel is down and the backup battery backup goes into deep discharge then a sensor starts the TEG as a backup power source until the Solar is up again. The TEG heat can be produced by a low-pressure flame fuelled by Propane or Natural Gas.

D. Formerly known as Global Thermoelectric (Canada), Gentherm Global Power Technologies (GPT) has hybrid solar-TEG solutions where the thermoelectric generator supports solar-PV, so that when the solar panel is down and the backup battery goes into deep discharge, the sensor starts the TEG as a backup power source until the solar is up again. A low-pressure flame fuelled by Propane or Natural Gas can produce the TEG heat.

E. Many space probes, including the Mars Curiosity rover, generate electricity using a radioisotope thermoelectric generator whose heat source is a radioactive element.

F. Automobiles and other vehicles generate waste heat (in exhaust and cooling agents). Using a thermoelectric generator to harvest that heat energy can boost the car's fuel efficiency. Refer to the article: Automotive thermoelectric generator for more information.

G. In addition to automobiles, waste heat is also generated in many other places, such as in industrial processes and in heating (wood stoves, outdoor boilers, cooking, oil and gas fields, pipelines, and remote communication towers).

H. Microprocessors generate waste heat. Researchers have considered whether some of that energy could be recycled.

I. Solar cells use only the radiation's high frequency portion, while the energy of low frequency heat is wasted. Several patents have been submitted regarding the use of thermoelectric instruments in tandem with solar cells. The concept is to make the mixed solar / thermoelectric system more efficient in order to transform the solar radiation into useful electricity.

J. The Maritime Applied Physics Corporation in Baltimore, Maryland is designing a thermoelectric generator to generate electricity on the deep-ocean offshore seabed using the temperature distinction between cold seawater and hot fluids produced from hydrothermal winds, warm seeps, or geothermal wells. A highly reliable source of electrical seafloor power is needed by seafloor mineral and energy resource developers and the military for ocean observatories and sensors used in the geological, environmental and ocean sciences.

9. CONCLUSION

After completing this project, we would know at different temperature difference, different electricity value will be got. If it is used in industries than how much temperature difference is needed to generate 1v electricity. After doing this project we would know how thermo electric generator will work and what its principles. Whether it is valuable to put this Thermo electric generator in industries or not.

10. REFRENCE

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