Review of Thermoelectricity to Improve Energy Quality

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***Abstract*- The objective of this paper is to investigate the usefulness of the thermoelectricity and find out way by which we can convert low grade heat to high grade electricity. This analysis has been done by studying the basic fundamental of energy generation, energy conversion of the energy and the development and need of the conversion of energy from low grade to high grade. The relative advantages and disadvantages of thermoelectricity with other renewable and non renewable sources have also been done in this analysis. We have also made one conceptual thermoelectric solar generator model to study its capacity to convert the low grade solar heat to high grade electricity.**
Finally, it is concluded that thermoelectric technology is the new and very advantageous energy conversion method, but now a days this is in development phase but in future it may be proved as a non comparable energy conversion method.

***Index terms*: thermoelectric generator, thermoelectric solar generator, thermocouple, thermoelectric module, advantages and limitations of TEG, solar concentrator.**

I. INTRODUCATION

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers. The term "thermoelectric effect" encompasses three separately identified effects: the Seebeck effect, Peltier effect, and effect. The Seebeck effect is the conversion of temperature differences directly into electricity. The Peltier effect is the presence of heating or cooling at an electrified junction of two different conductors. Thomson effect describes the heating or cooling of a current-carrying conductor with a temperature gradient. But our area of interest is seebeck effect. The Seebeck effect is used in thermoelectric generators, which function like heat engines, but are less bulky, have no moving parts, and are typically more expensive and less efficient. They have a use in power plants for converting waste heat into additional electrical power (a form of energy recycling) and in automobiles as automotive thermoelectric generators (ATGs) for increasing fuel efficiency. now days new trend is to use this science to convert solar heat into electricity directly. But because of less efficiency this science is used as only to measure a temperature because its use as energy source is in development phase. Thermocouples and thermopiles are devices that use the Seebeck effect to measure the temperature difference between two objects, one connected to a voltmeter and the other to the probe. The temperature of the voltmeter, and hence that of the material being measured by the probe, can be measured separately using cold junction compensation techniques. Thermocouple is nothing but the pair of two different metals wire by joining their ends and by making it junction by fusing it. and when more than one thermocouple are joined in series to multiply the output then it is called as thermopiles. But now day's new semiconductor type thermopiles are used as energy generator because of its higher efficiency then conventional thermocouples or thermopiles, and they are known as thermoelectric modules as shown in figure.

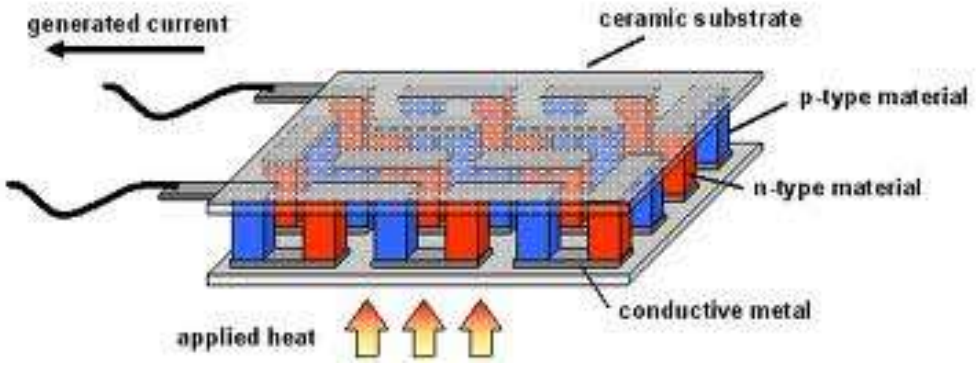

Fig.1. concept of thermoelectricity

II. TYPES OF ENERGY AND ENERGY CONSERVATION LAW

Energy conservation law: the energy neither be created nor be destroyed; only one form of energy converted in another form, and amount of energy in the world is constant.
But this low is true only for quantity of the energy, but not true for quality of the energy. In actual situation, during every use (conversion of energy) quality (grade) of the energy is decreasing .so to convert the low grade energy into high grade to regain its usefulness.

Two types of energy according to use

Use of energy is one type of conversion of the energy.
1. High grade energy: the energy which can be converted completely from one form to another form. (e.g.: electricity)

2. Low grade energy: the energy which can't be converted completely from one form to another form. (e.g.: heat)

We have studied the thermoelectricity for this purpose. we have conducted one experiment on conceptual model of thermoelectric generator, in which we have used solar heat as a low grade energy and tried to convert it into high grade electricity.

Specifications of our model and constructional detail

1. Source of low grade heat for hot junction:

- Solar concentrator

  Type: parabolic dish type concentrator

  Reason: high concentration ration-2000 to 3000

2. Reflecting material for concentrator:

- aluminium foil (Reynolds aluminium wrap)

  Reason: reflectivity is around 0.9, economical, easily available

3. Cooling system for cold junction:

- natural circulation of water

  Reason: force circulation needs power consuming pump

4. Thermoelectric module:

- semiconductor TEG module

  Reason: higher efficiency (can generate 1V emf per 80 degree

  Temperature gradient)

Experimental analysis: This result is taken on conceptual model of thermoelectric solar generator. The output can be multiplied by bigger practical model.

Fig.2. conceptual experimental setup

Specification of conceptual model:

Diameter of opening of the parabola (concentrator) =**1.47 m**
Surface collecting of the parabola (concentrator) = **1.78 m^2**
Depth of the parabola (concentrator) = **0.22 m**
Focal distance f =**0.61 m**
Experimental result:

Hot junction temperature (Celsius)	Cold junction temperature(Celsius)	Temperature gradient	Output voltage
50	30	20	0.35
70	30	40	0.5
90	30	60	1.0
110	30	80	1.5

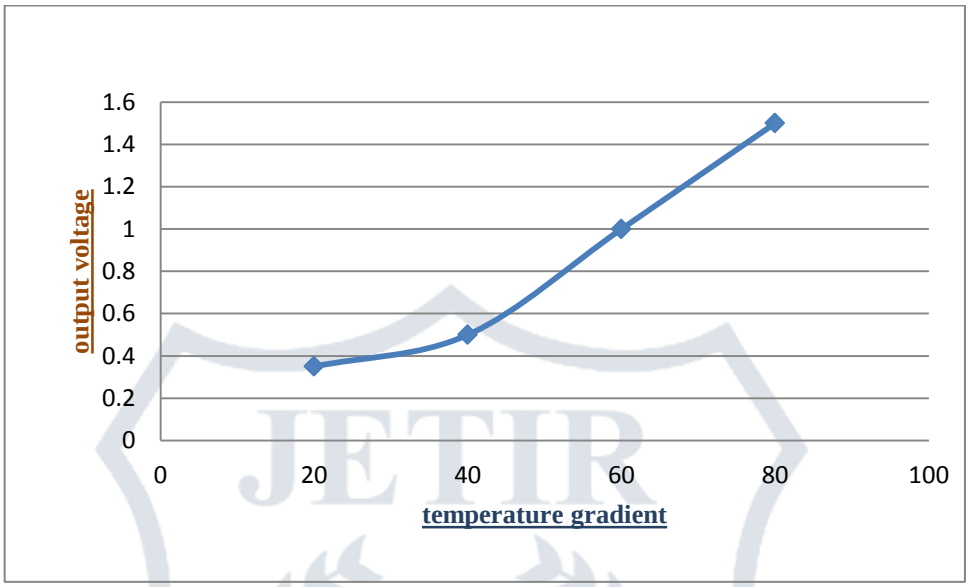

Fig.3.graph of experimental readings

III. LITERATURE REVIEW

1. **ROBERT W. FRITTS (1967)**: A summary of the development of gas-fired thermoelectric power plants is given for the period from 1962 to 1966. Present-day thermoelectric generator equipment is portrayed with a description of good site preparation and installation steps showing the simplicity of operation. The power cost per kilowatt hour is portrayed for present-day equipment and compared with conventional power sources. All probable uses are summarized and a projection is given for the power range that thermoelectric generators will occupy in competition with other direct energy conversion devices in the foreseeable future.

2. **Aryan Kumar (2014):** 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. Thus we aim to develop a cheap and more efficient thermoelectric generator module to harvest energy from automobiles and to provide a cheap tool to the rural area to light their homes by the use of model like BioLite stove in India. Future developments in this area might focus onto finding more suitable thermoelectric materials that could handle higher temperatures from various heat sources at a feasible cost with acceptable performance.

3. **K. Wojciechowski:** Automotive engines reject a considerable amount of energy to the ambience through the exhaust gas. Significant reduction of engine fuel consumption could be attained by recovering of exhaust heat by using thermoelectric generators. One of the most important issues is to develop an efficient heat exchanger which provides optimal recovery of heat from exhaust gases. The designed model of heat exchanger allowed for the utilization of 0.6 to 5.0 kW of exhaust gas energy depending on the operating parameters of the engine. However, the analysis of temperature distribution points out that, upon introduction of specific changes into the design, it is possible to recover even 25 kW of heat energy. Assuming the 5% efficiency of the thermoelectric modules it could allow to obtain the maximum electric power of app. 750 W. This power is comparable to the power of typical alternators used in cars with 1.3 dm3 engine capacity. It should be expected that much greater generator performance can be obtained by building it in the exhaust system of spark ignition engine types, due to the higher temperatures of exhaust gases. This sort of research is going to be continued in the nearest future.

4. **H.N. Fan (2010):** An experimental prototype of concentrator thermo electric generator using parabolic dish concentrator of 1.8 m diameter (CTEG), two-axes linear tracking system, liquid cooling system and BiTe thermo electric generator have been fabricated. It was expected that was formulated on the basis of energy balance predicted that maximum power of 64 W can be produced from the 1.8 m dish while maintaining the cell temperature below 250 °C. Lab tests under controlled experimental conditions were conducted in which maximum power of 4.8W from single thermo electric generator at temperature difference of 110°C and 2.9% conversion efficiency was produced. The assembled system as the CTEG is able to produce electric power

of up to 5.9W under the temperature difference of 35°C. The research about testing the latest TE material under the current CTEG system is recommended so that for this particular area, the concentrator thermo electric generation can be considered as a perspective candidate of the renewable energy based power source.

5. **Basel I. Ismail (2009):** 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. Enormous quantities of waste heat generated from various sources are continuously 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, which presents itself as a promising alternative green technology, has been successful used to produce electrical power in a range of scales directly from various sources of waste-heat energy.

IV. CONCLUDING REMARK :

1. Some literatures say that, thermoelectricity is the feasible option for conversion of energy from low grade(heat) to high grade(electricity),and this is very advantageous because of direct conversion without any moving parts.
2. Some literatures show that, as a best feasible option of energy conversion thermoelectricity can be used as renewable energy sources by merging it with solar concentrating energy.
3. This technology is now in development phase, and need improvement to increase its efficiency by research of new thermoelectric semiconductor materials.

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