IETE Zonal Seminar "Techno-Socio Development through Women Empowerment" - 2018
Special Issue of IJECSCSE, ISSN: 2277-9477

Solar Operated Thermoelectric Power Generator

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Abstract **— In today's world power is major crisis among human beings, for industrial purpose and for human requirements. In our country demand of power is increasing tremendously so fuel that we use for power is at the edge of extinction, so that alternative resources are used to generate high and sufficient amount of power. Solar energy present in abundant for supplying the worlds energy needs. Development of solar concentrators and thermoelectric power generator will bring a commercial solar energy concentration technology in the near future. The generator works on Seebeck effect. Effect state that when two dissimilar metals junctions placed at different temperature would produces an electric potential. The generator consist of a ceramic substrate used for withstanding high temperature, two metal plates which should be chosen on basis of thermal conductivities, semiconductor module for circuit completion and inverter battery setup for staring energy. It also requires lenses for concentration of solar radiation. By using this small setup we can obtain 6 Volt of power. When large plant will get installed then we can obtain high power by using renewable solar energy.**

Key Words — Ceramic Substrate, Manual solar Tracking, Seebeck Effect.

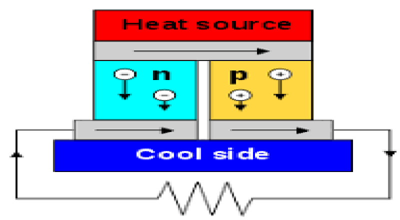
I. INTRODUCTION

Solar energy is the one of abundant renewable energy source present on the earth for feeding power requirement. The effective method for utilizing solar energy is concentrating the solar radiation and generates energy. Thermoelectric devices are the commercial new technology to utilize the concentrated solar radiation and generate electricity [1]. Thermoelectric materials are easy to handle and less production cost makes them as a useful devices for generating power from renewable energy sources, waste heat from other devices such as biomass, [3] exhaust from I. C. engines. As the devices have low efficiency but to utilize abundant solar energy as well as waste heat thermoelectric devices are beneficial. Thermoelectric device works on thermoelectric effect i.e. Seebeck effect. Diffusion of charge carriers produces a potential difference due to creation of temperature gradient across two terminal of thermoelectric device due to heat dissipation. The reaction also takes place in reversible manner also i.e. when current flows in a two different junction of TE device the temperature difference produce heating and cooling effect on both sides.

II. BACKGROUND

A. History of Thermoelectricity

Thermoelectricity has come in existence in 1820-1920. In 1822 the German scientist Thomas Johann Seebeck discovered the Seebeck effect which forms the base of development of thermoelectricity [1].



B. Seebeck Effect

Seebeck found that a circuit made from two dissimilar metals at different temperature would deflect a compass magnet. [1] This effect has long been used in thermo couple to measure temperatures. As the voltage produced is proportional to temperature difference between the metal junctions. Constant is termed as Seebeck coefficient (α).

C. Thermoelectric Materials

The following materials have been found suitable for use in thermoelectric elements. [2] Lead telluride (PbTe), in n and p type forms, bismuth telluride (Bi_2Te_3), bismuth sulfide (Bi_2S_3), antimony telluride (Sb_2Te_3), tin telluride (SnTe), indium arsenide, germanium telluride (GeTe). Lead telluride (PbTe), and bismuth telluride (Bi_2Te_3) has been commonly used in recent times for thermoelectric converters. However, the proportion of heat supplied that is converted into electrical energy is only about 5 to 7 per cent. Efforts are being made to provide more efficient thermoelectric materials.

Table -1: N-type material groups by best temperature range [4]

Group	Material	BTR(K)
Hot Side Material (700 K-1000 K)	CeSb	650-1100
	PbTe	600-850
	SiGe	>1000
Cold Side Material (300 K-400 K)	Bi_2Te_3	<350

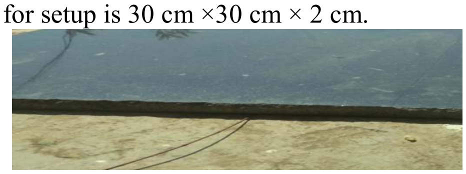
Table -2: P-type material groups by best temperature range [4]

Group	Material	BTR(K)
Hot Side Material (700 K-1000 K)	Zn_4Sb_3	>600
	$CeFe_4Sb_{12}$	>850
	SiGe	900-1300
Cold Side Material (300 K-400 K)	Bi_2Te_3	<350

III. EXPERIMENTAL SETUP

Granite

Granite is a coarse grained rock which is mineralogical composing predominantly of feldspar and quartz. It can be used as a heat source which entrapped the solar intensity and it has ability to withstand high temperatures up to 300^0 C. Thermal conductivity for the stone is 8 W/M ^{0}C. Dimension of stone for setup is 30 cm ×30 cm × 2 cm.



. Fig -2: Granite

Copper and Aluminium Strips

Strips are of same dimensions as of granite. Strips are placed beneath the stone for attaining the high temperature from the stone. Copper strip acts as hot terminal and aluminium strip for cold terminal for thermoelectric module. Thermal conductivity for copper is 385 W/M^{0}C

Heat Sink

A galvanized tank of dimension 40cm × 40cm × 7cm is used as a heat sink for the experiment. The water and brine solutions are the two cooling medium which are being used for maintaining temperature less than hot plate for creating temperature difference for voltage generation.

. Fig 3: Heat sink with strips

Thermoelectric Module

Module consists of two ceramic substrate which forms the base and protective insulation for both n-type and p-type semiconductors. Both electrons and holes constitute as a charge carrier for generating voltage. [5],[6], Thermoelectric material bismuth telluride (Bi_2Te_3) is placed between two ceramic made from alumina (Al_2O_3) forms thermoelectric generator i.e. module. Specification of module is 4 cm × 4 cm × 0.4 cm. 12 V modules with maximum 6.4 A current.

Table -3: Performance of Module

Specification	Performance
Max hot side temperature	250 ^{0}C
Max current (A)	6.4
Max voltage (V)	14.4
Module resistance (Ohms)	1.98

Manual Solar Tracking with Fresnel lens

For tracking mechanism a simple mechanism is used which consist of a plane convex lens for concentrating the solar radiation.

Table -4: Lens Specification

Lens type	Plane convex
Focal length	300 mm
Lens material	polyvinyl-chloride(PVC)
Length	250 mm
Width	175 mm
Depth	0.4 mm

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Battery and Inverter

6 Volt lead storage battery is used for storing the generated electricity. A D.C. rechargeable battery is used for experimentation. 6 Volt inverter kit is also required for conversion of direct current into alternating current.

IV. WORKING

Concentration of solar radiation occurred due to solar lens and which generate heat on granite. The stone act as a continuous heat source and transfer heat to copper strip. Strip is a hot junction followed by module and aluminium strip as a cold junction the voltage is developed within modules which are connected in series. The voltage is applied on terminal of a lead storage battery an inverter kit is used for converting direct current into alternating current and then load can be applied.

CONCLUSION

Fossil fuel sources are limited for today's world. Electrical energy is base of development. By using renewable solar energy the generator cam develop 6 Volt of electrical energy, while large thermoelectric generators can generate a high electrical power by using solar energy.

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