Utilization of TEG in Thermoelectric Energy Harvesting

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Abstract: This paper presents thermal energy harvesting from the hot (outer) surface of charcoal furnace which would be wasted in the environment. Due to the increase in demand of squat power devices, it becomes very significant to harvest unused ambient energy available in the environment. Depending up on the temperature difference Thermoelectric module convert Thermal energy into electrical energy. Using amplifier circuit and voltage booster the 3.86 voltage generated from TEG module is step up in to 12 volts. This voltage can be directly used or stored for later use in 12 Volt battery. In this work the voltage stored in 12-volt battery is utilized to power lamp and for mobile charging.

Keywords: ***Temperature, dissipated heat ,TEG, semiconductor***

I. INTRODUCTION

In recent days small power electronics devices and sensors are energised by the energy scavenging from the environment. Using the renewable energy sources, it is also viable to reduce the corban emission in the environment. Renewable energy sources like solar, wind, tidal and biogas used to generate the electricity in the range of MW to Watt. Other hand to power the small power devices energy scavenge is another option which creates the power in the range of micro Watt to milli Watt.

Energy scavenging is nothing but the process of gathering the unused energy from the environment and convert it in to electricity for direct use or stored for later utilization to power small electronics devices. The energy scavenging is nothing but an energy harvesting. Similar to the renewable energy sources there some energy harvesting sources like human movement, sun light, vibration mechanisms, radio frequency waves and thermoelectric energy generation. Various thermoelectric energy harvester is described in [1,2,3,4,5]. In case of the thermoelectric generation process the dissipate heat energy is converted in to electrical energy. For effectually translating the excess heat into electrical power using thermoelectric generators temperature difference is very important between the hot surface and cold surface such as ambient air. The resulted voltage is in few volts if the temperature dissimilarity in hot and cold surface is 10 or less than 10 degree [6]. To convert the low voltage in to required voltage there is need of converters which are single stage or double stage depends on the voltage application.

TEG devices are more effective over the conventional sources, in spite of their low efficiency. Their versatility in application of cooling and in power generation also makes them considerable over electrically powered devices. Since the voltage obtained from a thermoelectric generator is tiny, but by utilizing certain combinations of modules in series and parallel make the power generation comparatively efficient.

A Macro level thermal energy harvesting segment have been intended, fabricated, and analyzed [7].The device is verifiedat the temperature about 60 ^{0}C and results in 151.9 Joules of energy which is decent to operate a remote with 5% duty cycle.

In this paper a thermo electric energy harvesting method is described utilizing the excess heat generated from Charcoal furnace. This prototype generates 3.05 volts and 2.68 volts from industrial waste heat and automobiles respectively. This paper assembles in three sections as. Theory of thermoelectric generator, Set up for Heat recovery, experimental result and conclusion.

II. THEORY OF THERMOELECTRIC GENERATOR (TEG)

The TEG, also known as thermoelectric device/module ismade up of P-type and N-type semiconductor pellets connectedin series between two plates. The plates are typicallyfinished ofceramic or aluminium. The thermoelectric effects consist of three distinctly recognized effects: Peltier effect, See beck effect and Thomas effect [8]. When current passes through aintersection between two dissimilar electrodes, heat is formed or lost dependent

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on the polarityof the electric current. The amount of the heat formed or misplaced isproportional to the value of electric current flowing through the electrode. This result briefly designates the Peltier effect. This outcome is mostlyoriginating in refrigerators as it contains ofthermoelectric heat pump and thermoelectric cooling campaigns. Most of the thermal sensors are powered by the TEG module. Figure 1. shows the block diagram of proposed system.

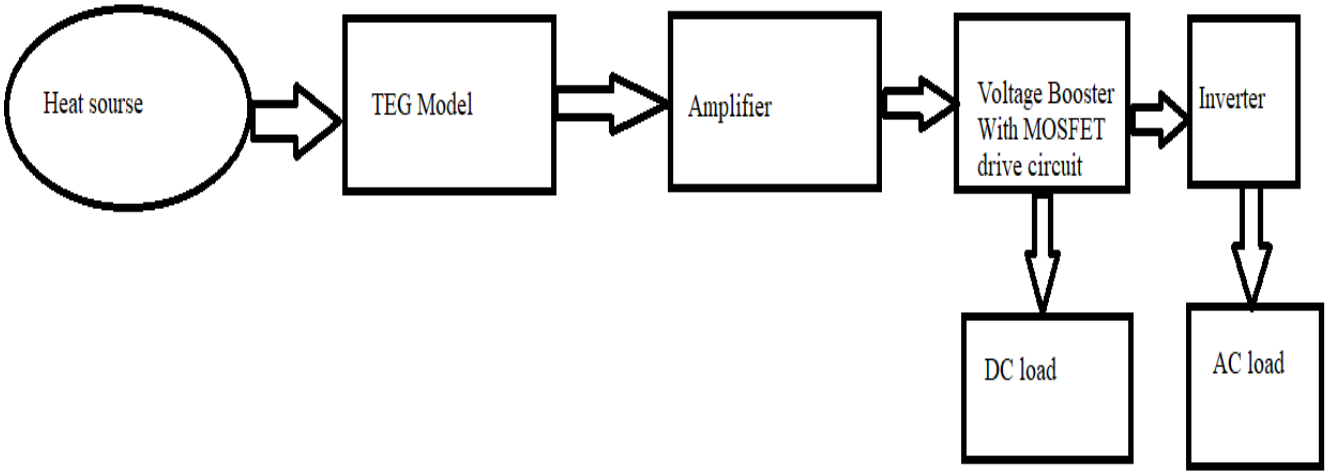


Fig.1.Block diagram of proposed system

Heat recovery set-up for charcoal furnaces

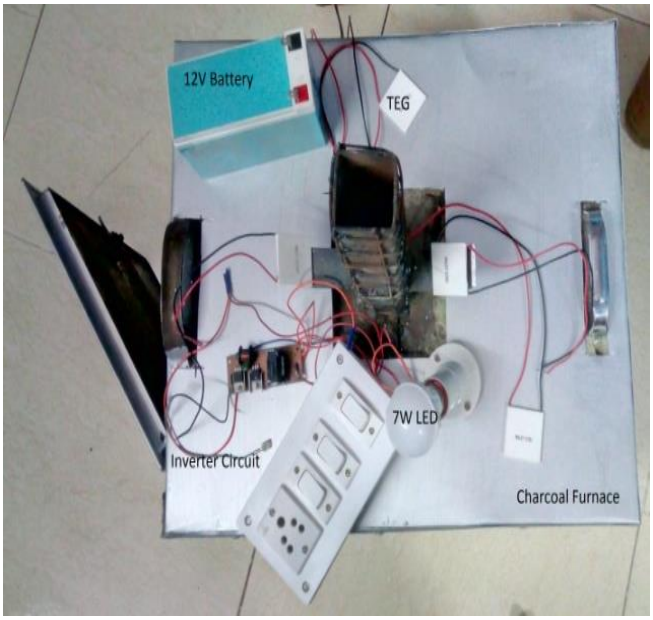
In heat recovery setup excess heat generated from the exhaust pipe of the charcoal furnaces is utilized. One of the sides of the TEG module is kept in contact with the exhaust pipe and the other sideit has the cold-water bottle. As the burning occurs in charcoal furnace, exhaust pipe starts to heat up and reach near to 150°C. This provides a good temperature gradient of about 70-80°C, thereby giving the enough output power to run small devices.

III. EXPERIMENTAL SET-UP

In this set up TEG module is connected between hot and cold junction. The hot and cold junction is made by charcoal furnace and cold-water bottle. The electrical energy is achieved in the range of 2V to 3V, utilizing the dissipated heat by the source. Then this voltage is amplified by using a voltage amplifier. This output voltage from the amplifier is boosted by using a boost converter. The boost converter involves of switched inductor, with MOSFET as a switching device. The PWM signals are provided from the PIC microcontroller, which is used to operate the MOSFET driver circuit. The MOSFET driver circuit provides high speed switching for the MOSFET in the boost converter. Based upon the switching, the energy deposited in the inductor and is delivered to the battery. A battery of the order of 12V is connected across the output power. An inverter circuit also connected to the battery to convert DC volt in to AC to which a lamp and mobile charger is connected.

IV. EXPERIMENTAL RESULT

The wasted heat from the charcoal furnace is monitored by thermocouple in the range of 150^{0}C at hot surface and 67 ^{0}C at cold surface. Due to the variance in Temperature of 68 ^{0}C TEG module convert differential temperature in to electrical energy of 3.68 V DC after 1hr of operation. Then this voltage is amplified by using a voltage amplifier which resulted in 5V DC. This output voltage from the amplifier is boosted by using a boost converter consisting MOSFET driver circuit results in 12 V DC.



(a)

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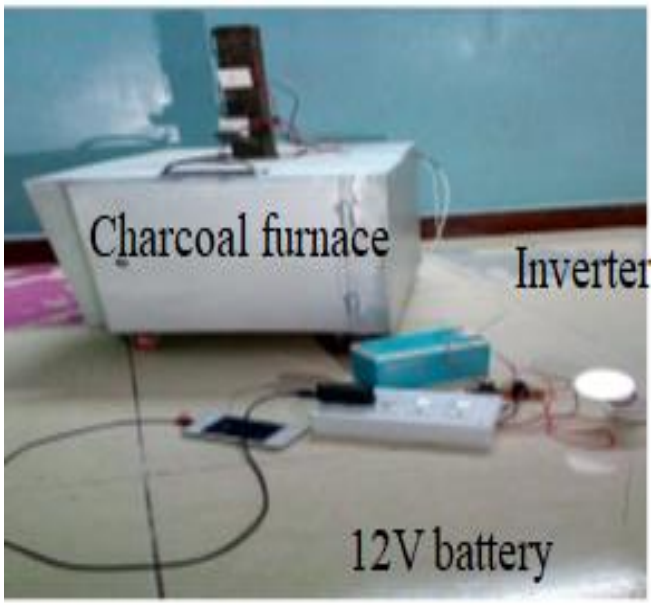

(B)

Fig.2. Experimental set-up (a) Top view (b) Side view

TABLE I. RESULTS OF THE EXPERIMENTAL SET-UP SHOWN IN FIGURE 2

Heat source	Outer surface of Charcoal furnace
Temperature at hot surface	135^0C
Temperature at cold surface	67^0C
Temperature difference	68^0C
DC voltage produced by TEG after 1hr. operation.	3.68 V

V. CONCLUSION

This paper provides simple and efficient way of thermoelectric energy harvesting which further utilize to charge a mobile phone and to glow 7Watt LED lamp. It is also possible to generate 3.86V at temperature difference of 67 ^{0}C which amplified and boosted in 12V DC. The main pivot of this paper is on converting waste heat energy from charcoal furnace into electric energy that can be stepped up to obtain more voltage. The TEG is used in military as well as aerospace applications from decades. By using new TEG materials the systems are being advanced to produce efficient electric power, by means of both either low or high temperatures of dissipated heat. It is possible to provide a more opportunity in the near future. These systems adjustable to particulars like proportions, process and maintenance cost. Further investigation is needed to harvest more energy using reduced number of TEGs or by reducing the number of converter stages.

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