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Utilization of Furnace Heat for Generation of Electricity

Prof. Praful Kumbhare[1], Shubham Hargude[2], Akash Bhoyar[3], Lukeshwar Girhepunje[4], Akash Sangole[5], Yadav Musale[6]
[1, 2, 3, 4, 5, 6]*Electrical Engineering Department, Guru Nanak Institute Of Technology, Nagpur*

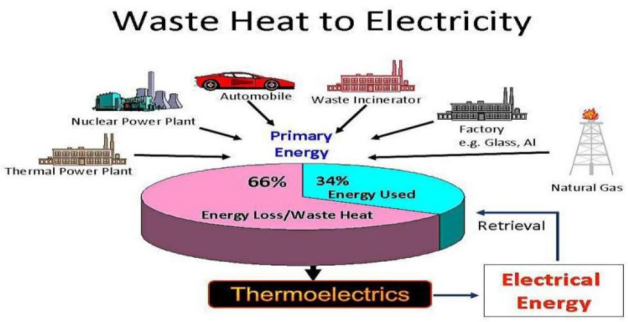
Abstract: ***This project deals with power generation from waste heat of the industrial heating furnace. The thermoelectric generator is used to utilize the furnace heat for converting heat energy into electric energy. The cooling system is designed for providing cooling to thermoelectric generator and water is used as a coolant. The industrial furnace data based has been analyzed on the basis of that, prototype model is designed. In this model, thermoelectric generator plates are connected in series and parallel to achieve the required output voltage level.***
Keywords: TEG (Thermoelectric generator), Temperature Sensor, DC-DC Boost Converter.

I. INTRODUCTION

The main objective of this project is to generate electricity from wastage heat of the industrial furnace. It has sent ample amount of harmful gas from light diesel oil (LDO) to our environment. The application of thermoelectric technology is used in this project. Thermoelectric generator (TEG) may offer direct conversion of heat into electricity. The uncertainty in the availability and reliability of fossil-based fuels has resulted in developments of energy saving and alternative sources. Utilization of fuels in industries and automotive engines results in more than 70% thermal energy being discharged into the environment as waste heat. If some of this waste heat could be recovered, the minimum or maximum amount of primary fuel could be saved. Therefore, In the energy conservation research, the thermoelectric conversion technology becomes an interesting work. The thermoelectric generator (TEG) modules to convert heat directly into electricity.

II. THERMOELECTRIC GENERATOR

A TEG (Thermoelectric generator) module is a solid-state device, on the base on "Seebeck effect" that provides direct energy conversion from thermal energy (heat) into electrical energy. The thermoelectric power cycle, with charge carriers serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine. The oldest technology behind this technology is Seebeck effect on Thermocouple now this tech using in Seebeck effect on semiconductors so it can eliminate wires, so wireless technology is possible. An important advantage in thermoelectric power generation using waste heat energy is to decrease the cost-per-watt of the devices. Moreover, cost-per-watt can be reduced by optimizing the device geometry, improving the manufacturing quality and simply by the difference.



Advantages of Thermoelectric generators as compare with other technologies -

1) They have very small size, weightless and the capacity to operating at elevated temperatures.
2) The source for the power generation is Heat not Light, so day and night operation is possible.
3) They have mostly used to convert the waste heat to electricity so it is considered as a Green Technology. We can increase the overall efficiency of the system (4% to 7%).
4) They can be alternative power sources.

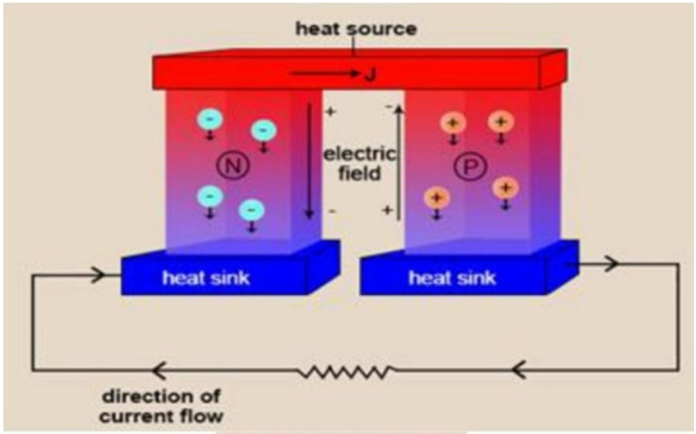
5) When compare to exciting conventional power system it requires less space and cost.

The theory behind Thermoelectric Power Generation

The basic concept behind the TEG is "Seebeck effect". Thomas Seebeck was discovered Seebeck effect in 1821. When a temperature difference is recognized between the hot and cold junctions of two dissimilar materials (metals or semiconductors) a voltage is generated, this voltage is called Seebeck voltage. When a Thermoelectric material is a place between temperature gradient it generated some voltage. In fact, this method is applied to thermocouples that are extensively used for temperature measurements. Base on this Seebeck effect, thermoelectric devices can act as electrical power generators.

A. Seebeck Effect

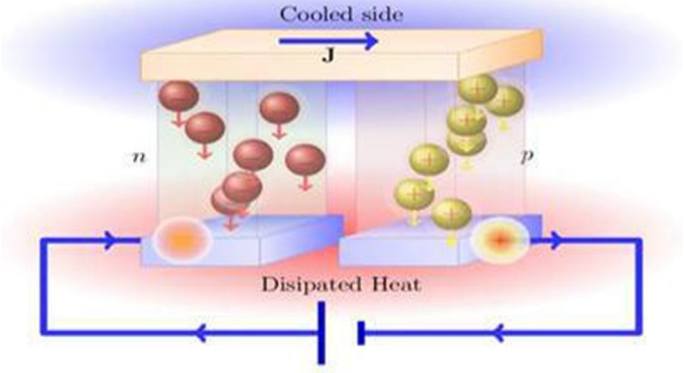
The Seebeck Effect state that electric current is produced when dissimilar metals are exposed to a variance in temperature. Seebeck effect applications are the foundation of thermoelectric generators (TEGs) or Seebeck generators which convert heat into energy. The temperature difference across between the two metal junctions is proportional to the voltage produced by TEG or Seebeck generators.



Seebeck Effect

B. Peltier Effect

The Peltier effect states that by applying a voltage between two electrodes connected to semiconductor material then temperature difference is to create. This effect can be useful when it is necessary to transfer heat from one medium to another on a small scale.



III. DESIGN / IMPLEMENTATION

In this chapter design and implementation of hardware, a project was discussed. The design is done on the basis of the rating of equipment. For conversion of thermal energy to the electrical energy various rating are taken into consideration. The block diagram of the project is shown below

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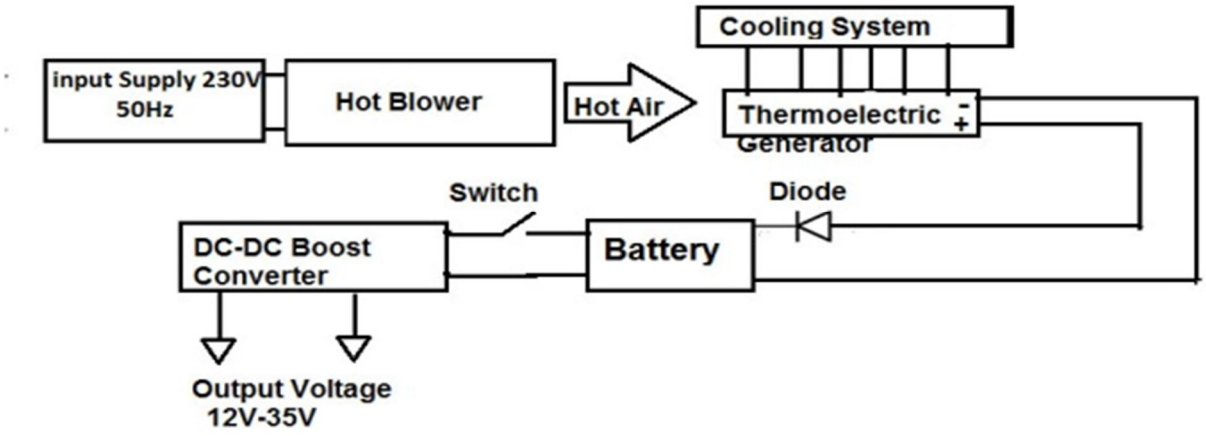
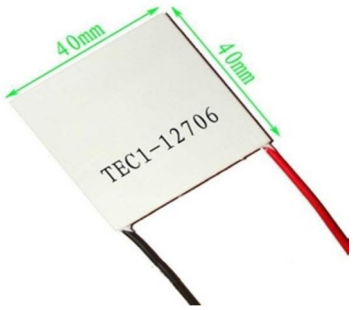
A. Block Diagram



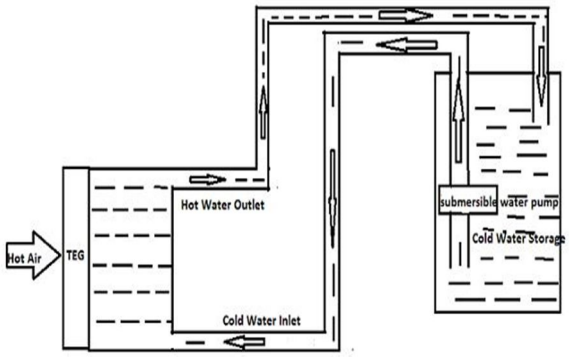
IV. TOOLS DESCRIPTION

A. TEG – Thermoelectric Generator



Thermoelectric generators could be used in power plants for conversion of waste heat into additional electrical power.

B. Cooling System



The function of a cooling system is to remove heat from the Cool side of TEG module. In this Project, we use water cooling System to cool another side of TEG module.

V. OPERATION

A. Two aluminum hollow pipe, one is considered as a furnace in which hot air is passed by using a hot blower and other pipe is used for cooling purpose.
B. The main component i.e. TEG- thermoelectric generator is placed between the two aluminum hollow pipe.
C. Input supply of 230 volts is given to hot blower, its uses for passing hot air in the hollow pipe.

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D. Then current will flow through thermoelectric generator plate, it has two sides, Hot and Cold. Hot side is connected with hot air blower and Cold side is connected to water circulating system. According to the requirement, both blower and water circulating system perform the operation.

E. For maintaining temperature Hot air flows from air Blower to One side of TEG module. A submersible pump is used to circulate the water and provide pressure to another side of TEG module.

F. Input supply of 12 V is given to temperature sensor. When temperature above temperature sensor setting then temperature sensor will OFF and, when reaching up to temperature sensor setting it will ON, this cycle repeats.

G. When the temperature of the hot hollow pipe increases the temperature sensor setting value then temperature sensor fed the instruction to relay.

H. The relay is used for cut off the circuit of the hot blower when the temperature is increased above the set value. (Relay is used in our model for protection purpose.)

VI. RESULT

This project is based on electrical power generation from waste heat of a heating furnace. Thermoelectric generator has been used to convert heat energy to electric energy. From Seebeck effect and Peltier effect, a Seebeck effect is implemented to absorb heat from a furnace. The cooling system has been designed and implemented for providing cooling to another side of the thermoelectric generator.

Experimental prototype model has been represented here in this project. From this model, it is found that Approximately 2V to 8V is generated from the temperature difference of 75°C. So we can comment that it is possible to generate approximately 150V to 160V from 1400°C waste heat of the furnace. But to achieve this voltage level, special type thermoelectric generator plate is required to design. The DC-DC converter has been implemented for boosting up the voltage from 8V to 23V approximately. So that, it is possible to boost up the voltage level from 150-160V to 450-480V.

When 4 TEG module connects the output is following

Sr. No.	Temp at Hot Side	Temp at cool Side	Temp Difference	Voltage
1	28.4	17	11.4	1.7
2	30	17.9	12.1	1.8
3	35	18.4	16.6	2.3
4	40	19.2	20.8	2.5
5	46	21	25	2.53
6	50	23	27	2.62

When 10 TEG module connects the output is following

Sr. No.	Temp at Hot Side	Temp at cool Side	Temp Difference	Voltage
1	33	30	3	1.49
2	35	30.1	4.9	1.90
3	40	30.3	9.7	2.37
4	43	30.8	12.2	2.40
5	45	31	14	2.42

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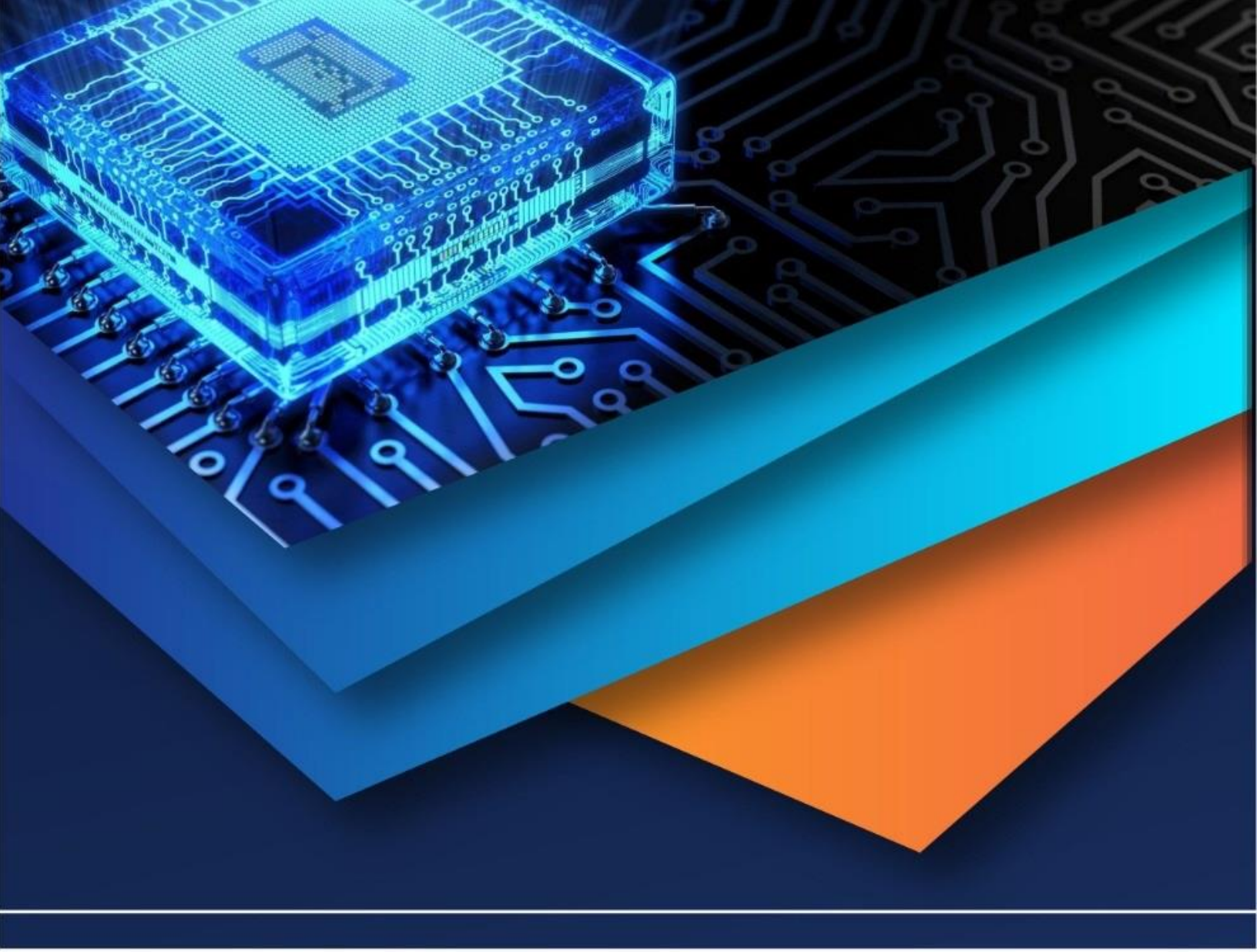

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