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Analysis of thermoelectric heat exchanger for Waste heat recovery by see beck law

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Abstract
Generating electricity from the waste heat is the main objective of the paper. The system may design by considering previous design of thermoelectric generator. The cost reduction and simplicity taken care for increasing energy generation efficiency. The energy may generate from the principle of see beck law and peltier's law. The thermocouple is tested and based on the results many thermocouples are connected in series to increase the voltage. The new optimum method applied to increase thermal difference of hot and cold surface of thermocouple and formed thermopile.

Keywords: Peltier effect, thermoelectric generator, waste heat recovery, Thomson effect

Introduction
The energy requirement in the current world drastically increases in day by day. Each new system analysed to reduce energy consumption as well as reduction of wasting of energy. The most energy wasting method is thermal energy. To reduce wastages of heat waste heat and energy conservation methodologies applied. The cogenerating methods most prefer now to generate electricity or using the energy to some other purposes like pressure, velocity and etc., one of these cogeneration methods is thermoelectric method. In this heat is directly converted into electricity. Other than steam power plant the life of waste heat plant is more and more compact. But the problem is very lower efficiency. To increase the efficiency various methods applied.

See Beck Law and Thermoelectric
This law stated to connect different metal junction connected in junctions of hot and cold the electrical motive force will generated. That energy need to increase to utilize for house hold. At the same time cost of thermoelectric modules cost is very high for smaller unit. The metals which using for module is cost very high. For development of thermoelectric in rural places is highly impossible to spending more money.

Material Analysis for Sampling Output
The sample may analyse based on the see beck coefficients and the sample temperature difference from hot and cold is 500oC.

Table 1.1:

S.No	Material Combination	Output Voltage
1	Sellinuim-telluriam	200
2	Silicon-germanium	70
3	Silicon-antimony	196.5
4	Nicrome-iron	3
5	Iron-molybtenum	4.5
6	Cadmium-gold	0.5
7	Tungsten-silver	0.5
8	Copper-lead	1.25
9	Aluminium-lead	-0.25

Based on the table 1.1 the metal cost is more for higher output parameters. When reduce the cost by using easily available metals like aluminium, copper, iron, lead the output voltage is very minimum.
The data analysed from the software application called Seebeck calculator, developed in National Instruments-LabVIEW 2011.
The software looks like as below in fig 1.1

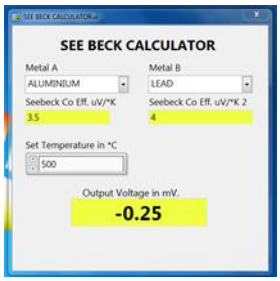


Fig. 1.1

The see beck coefficients are taken as lookup value and finally metals selected as Iron-copper and copper-nickle for the purpose of rural waste heat recovery.
But considering new methodology called copper oxide method thermoelectric generator more efficient to fabricate as well as simple in design.

Development of Thermoelectric Generator
The development of copper oxide thermoelectric generator in following steps.

- Sensor cooking
- Cleaning
- Testing
- Combining
- Testing connectivity

Sensor cooking
In this step copper wire is heated upto to red hot condition. The red hot copper wire will combined with atmospheric oxygen and forms the copper oxide.
The equation given as below.
Cu+02=> Cuo2
At this condition the colour modified when cooled in air to reddish colour. The fig 1.2 showing the cooking of copper wire

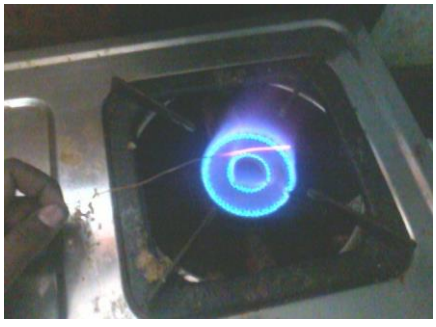


Fig. 1.2

The copper wire converted into partial manner and opposite side also did the same procedure.

Cleaning
In this step the cooked copper oxide wire is immersed for 5 minutes in cupric chloride to remove the carbon particles sticking in the surface of wire.

Testing
In the step the wire is tested for conductivity test using multimeter. If the dust particles found in the wire it shows some readings and not giving sound. So the wire again immersed in cupric chloride and the wire surface is removed with scribers.

Combining
In this step the thermocouples are connected together in series. To increase the output voltage this is mandatory. If we connect the thermocouples in parallel method the output will come as average of voltage. To avoid that cold junction wire end is connected to just down to hot sensing region. This enables emf movement in all the wires.
The basement is prepared for setting up the copper oxide.

The fig 1.3 & 1.4 shows as below.

The output ranges as shows in graph 1.1.

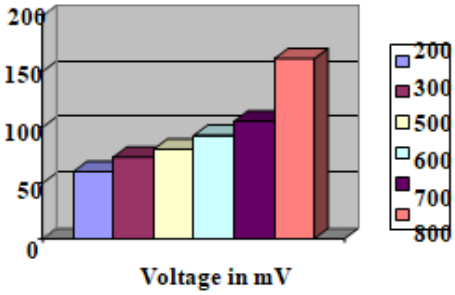
The output values modified by increasing cooling efficiency by adding aluminium pins on the cooling side. So the total values of output modified about 1.5 times.
The table 4.2 shows the output values comparison.

The output value measured in different temperatures as below in table 1.2

Table 1.2

S.No	Temperature in ^{o}C	Voltage in mV
1.	200	60
2.	300	73
3.	500	80
4.	600	92.5
5.	700	105.1
6.	800	161.3

Output from the System



Graph 1.1

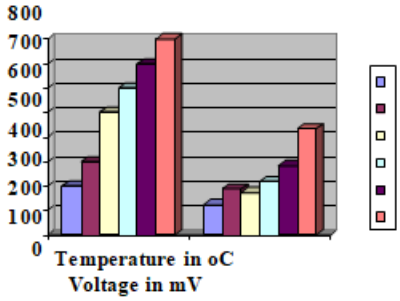
Table 1.3

S.No	**Previous Copper oxide-copper oxide design**	**Copper oxide-aluminium cooled design**
	At the temperature of 500oC	
1.	60 mV	150mV

Fig 1.4

So the output drastically improved. Then the new design modified by applying aluminium fin in all the cold junctions the output voltage as measured in table 1.3

Output From Modified Thermoelectric Generator



The graph made from the above results in Graph 1.2

V.Optimization of Output Voltage in Thermoelectric Generator

The the circuit developed to utilize the minimum output to maximum rate of energy called Joule's thief. As the name mentioned, the circuit modify the output by storing the output in the coil and delivering to the system. The ciruit design developed in circuit simulator 1.5v.The circuit design given in below fig 1.5.

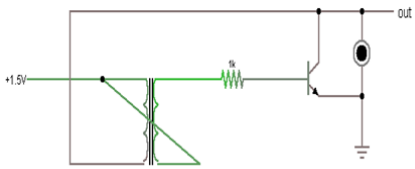


Fig 1.5

This ciruit contains three components,

- 1k Resistor
- 1:1 turoid coil
- 2N2222 philips made NPN transistor
- Testing LED range 3V.

This ciruit drives the LED at the frequency of 50 kHz. So the values of ON/Off cannot determine by our ordinary eye site.

Conclusion

The developed model of thermoelectric generator is very low cost to develop when comparing marketing thermoelectric modules cost about Rs.2500. but this can be developed from available waste copper wire and aluminium. The circuit that used for increasing the voltage can be utilize for rural electrical energy development. At the same time increasing the stages of this generator industrial waste heat will going to drive smaller industrial bulbs and coolers will increase the plant efficiency.

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