International Conference on Mechanical Engineering and Renewable Energy 2015
(ICMERE2015) 26 – 29 November, 2015, Chittagong, Bangladesh

ICMERE2015-PI-066

POWER GENERATION BY USING CANDLES

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***Abstract**- The aim of the project is to design and fabricate a power generating system by using candles. This report provides a practical introduction to the conversion of heat energy into electricity. A certain amount of heat can be converted into electricity which can help in our power crisis. By connecting a number of thermoelectric modules in series a good amount of power could be generated. If the temperature difference (hot side temperature – cold side temperature) increases it increases the output power. From single candle wax we generate 0.323W and from two candles 1.25W which is sufficient to run a 3V DC motor and some LEDs.*

Keywords: power generation, Seebeck effect, thermoelectric module, candles.

1. INTRODUCTION

Power Crises in Bangladesh are developing day by day. So, this is our small step to try to improve this situation by our project. It is a very old idea, electricity from a temperature difference. The effect is called "thermoelectric effect" or "Seebeck effect" [1]. A thermoelectric circuit composed of materials of different Seebeck coefficient (p-doped and n-doped semiconductors), configured as a thermoelectric generator [2]. Thermoelectric generators convert energy from heat into electricity by existence of the Seebeck effect. It is also used for integrated circuit thermal management [3]. A thermoelectric module is a semiconductor-based electronic component that functions as a small heat pump. The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one. If the pair is connected through an electrical circuit, direct current (DC) flows through that circuit. Commonly used thermocouple metal includes copper, iron, chromel and aluminum. Both N-type and P-type Bismuth Telluride thermoelectric materials are used in a thermoelectric cooler. This arrangement causes heat to move through the cooler in one direction only while the electrical current moves back and forth alternately between the top and bottom substrates through each N and P element. N-type material is doped so that it will have an excess of electrons and P-type material is doped so that it will have a deficiency of electrons. The extra electrons in the N material and the "holes" resulting from the deficiency of electrons in the P material are the carriers which move the heat energy through the thermoelectric material. Most thermoelectric cooling modules are fabricated with an equal number of N-type and P-type elements where one N and P element pair form a thermoelectric couple. An applied temperature gradient across the generator will force heat to flow from the hot to cold side by thermal conduction while some of this heat is converted to electricity. By converting the lost heat into electricity, ATEG (Automotive Thermoelectric Generator) decreases fuel consumption by reducing the electric generator load on the engine [4]. ATEGs allow the automobile to generate electricity from the engine's thermal energy rather than using mechanical energy to power an electric generator.

2. DESIGN

Four stainless steel rods of equal sizes are embedded in a base. The base structure is made of wood. Two aluminum angles (1″ by 1″) are fitted on these rods. In the hot side of the thermoelectric cooler aluminum fin are used which absorbs more heat from the candles. It reduces the heat loss from the candles. The length of the aluminum angles and aluminum fin should be equal for perfect fittings. In the cold side of the module an aluminum pot is kept which is filled by water. As a result heat flows from the hot to cold side.

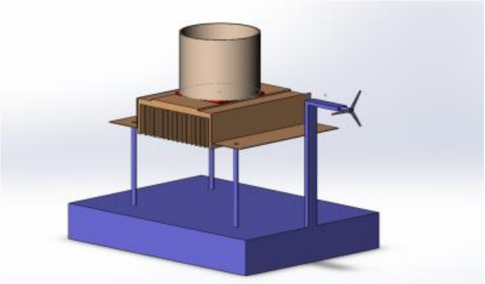

Fig.1: Isometric view of model

2.1 Necessary Equipments

i. Mechanical equipments
  - Glass Frame
  - Wood piece
  - Al angle
  - Expansion Springs
  - Heat Sink (CPU cooler)
  - Aluminum Pot
  - Candles

ii. Electrical equipments
  - TEC Module
  - DC Motor
  - Switches
  - Multimeter

2.1.1 Thermoelectric module (TEC Module)

A thermoelectric module is a semiconductor-based electronic component that functions as a small heat pump. A practical thermoelectric module generally consists of two or more elements of n and p-type doped semiconductor materials that are connected electrically in series and thermally in parallel. These thermoelectric elements and their electrical interconnects typically are mounted between two ceramic substrates. The substrates hold the overall structure together mechanically and electrically insulate the individual elements from one another and from external mounting surfaces. Most thermoelectric modules range in size from approximately 2.5-50 mm (0.1 to 2.0 inches) square and 2.5-5mm (0.1 to 0.2 inches) in height. A variety of different shapes, substrate materials, metallization patterns and mounting options are available.The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one. If the pair is connected through an electrical circuit, direct current (DC) flows through that circuit. The voltages produced by Seebeck effect is small, usually only a few microvolts (millionths of a volt) per kelvin of temperature difference at the junction. If the temperature difference is large enough, some Seebeck-effect devices can produce a few millivolts (thousandths of a volt). Numerous such devices can be connected in series to increase the output voltage or in parallel to increase the maximum deliverable current. The Seebeck effect is responsible for the behavior of thermocouples. Commonly used thermocouple metal include copper, iron, chromel and aluminum. There are several types or numbers of TEC module. One of them is TEC1-12706.

- Couples: 127
- Umax (V): 15.2V
- I_{Max} (A): 6A
- T_{Max} (degree Celsius): 67
- Dimensions: 40mm x 40mm x 3.5mm
- Power cable: 32cm
- Max. power consumption: 91.2W

Operating Conditions:

1. Maximum operating temperature: 138°c.
2. Life expectancy: 200,000 hours.
3. Do not exceed I_{Max} or V_{Max} when operating.
4. Failure rate based on long time testing: 0.2%.

3. WORKING PRINCIPLE

After burning a candle the aluminum heat sink begins to absorb heat. The temperature of the fin rises. As a result, temperature differences between the hot and cold junctions increases. Consequently the output voltage and current or in other words, the net output power increases. There is a multimeter parallel to the loads. If the lights or fan get the required voltage they will run.

Fig. 2: Powering lights.

Fig. 3: A 3V DC fan

4. DATA ANALYSIS

Thermal conductivity of aluminum, k= 237 J/K/m$^{2.}$

Area calculation of the CPU cooler:

1. Fin blade: It consists of 2 parts

For Part 1

Length = 9cm = 0.09m
Width = 2.3cm= 0.023m
Thickness= 0.8mm =0.0008m
Area, A_1= 0.09×0.023= 0.00207m²

For part 2

Length = 8.3cm = 0.083m
Width = 0.6cm= 0.006m
Thickness= 0.8mm = 0.0008m
Area, A_2 =0.083×0.006= 0.000498m^2

Area of one fin blade, $A = A_1+A_2$
= (0.00207 + 0.000498)m²
= 0.002568 m²

No of fin blades = 15

Total area of the fin blades = 15×0.002568 m² = 0.03852m²

2. Upper portion of the fin : 3 portions

For 2 similar parts

Length = 8.3cm = 0.083m
Width = 1.2cm= 0.012m
Thickness= 4.5 mm = 0.0045m
Area = 0.083×0.012 = 0.000996m²
No of the surfaces = 2

Total Area = 2×0.000996 m² = .001992m²

Another surface of thickness 6.5 mm

Length = 8.3cm = 0.083m
Width = 4.3 cm= 0.043m
Thickness= 6.5mm = 0.0065m
Area = 0.083×0.043= 0.003569m²

3. Side portions: It consists of 3 parts

Part 1

Length = 8.3cm = 0.083m
Width = 0.7 cm= 0.007m
Area = 0.083×0.007= 0.000581m^2

Part 2

Length = 9cm = 0.09m
Width =1.2 cm= 0.012m
Area = 0.09×0.012= 0.00108m^2

Part 3

Length = 9cm = 0.09m
Width = 1cm= 0.01m
Area = 0.09×0.01= 0.0009m^2

Area of the one side portion = 0.000581 + 0.00108 + 0.0009 = 0.00251m^2

No of the side portions = 2

Total area for the side portions = 2×0.00251 m^2 = 0.005122 m^2

Total area of the aluminum fin, A = (0.03852 + 0.001992 + 0.003569 + 0.005122) m^2 = 0.049203m^2.

Table 1: Data table for single candle.

SL NO.	Water temp. T1 (cold side) (°c)	Al Heat sink temp. T2 (hot side) (°c)	Delta temp. ΔT= (T2-T1) (hot side –cold side) (°c)	Qin = k×A× ΔT (J)	Time t (s)	Input power Pin =Qin /t (W)
1	21	41	20	233.22	420	0.55
2	24	46	22	256.54	450	0.57
3	26	70	24	279.89	470	0.59
4	30	79	49	571.37	945	0.60
5	33	86	53	618.04	990	.624
6	35	99	64	746.3	1072	0.69

Table 2: Input energy vs. output energy.

SL NO.	Input power Pin =Qin/t (watt)	Output voltage Vout (V)	Output current Iout (A)	output power Pout P=VI (W)	Efficiency η (%) = Pout/Pin
1	0.55	0.5	0.023	0.0115	0.021
2	0.57	0.75	0.047	0.03525	0.062
3	0.59	1	0.052	0.052	0.087
4	0.60	1.25	0.145	0.18125	0.299
5	.62	1.5	0.158	0.237	0.379
6	0.69	1.7	.19	0.323	0.464

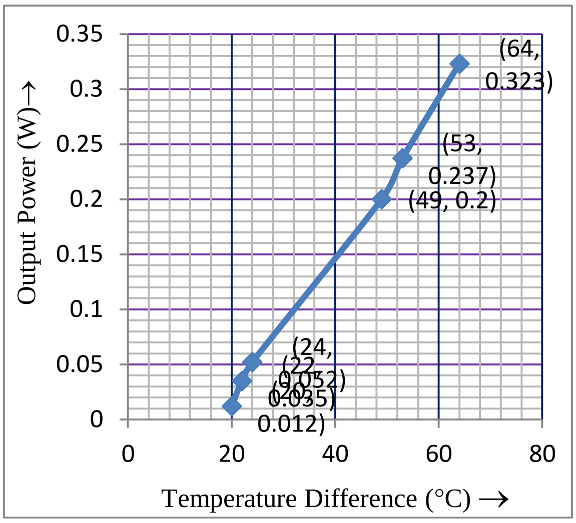

Fig.4: Output power VS temperature difference for single candle.

Table 3: Data table for double candle.

SL NO.	Water temp. T1 (cold side) (°c)	Al Heat sink temp. T2 (hot side) (°c)	Delta temp. ΔT= (T2-T1) (hot side –cold side) (°c)	Qin = k×A× ΔT (J)	Time t (s)	Input power Pin =Qin /t (W)
1	24	90	66	769.63	300	2.57
2	29	130	101	1177.8	345	3.41
3	34	166	132	1539.2	376	4.09
4	37	185	148	1725.8	418	4.13
5	39	201	162	1889.0	445	4.25
6	42	214	172	2005.6	460	4.36

Table 4: Input energy vs. output energy.

SL NO.	Input power Pin =Qin/t (watt)	Output voltage Vout (V)	Output current Iout (A)	output power Pout P=VI (W)	Efficiency η (%) = Pout/Pin
1	2.57	1.6	0.175	0.28	0.112
2	3.414	1.8	0.267	0.48	0.142
3	4.09	2	0.36	0.72	0.176
4	4.13	2.25	0.4	0.9	0.218
5	4.25	2.4	0.45	1.08	0.254
6	4.36	2.6	0.48	1.25	0.287

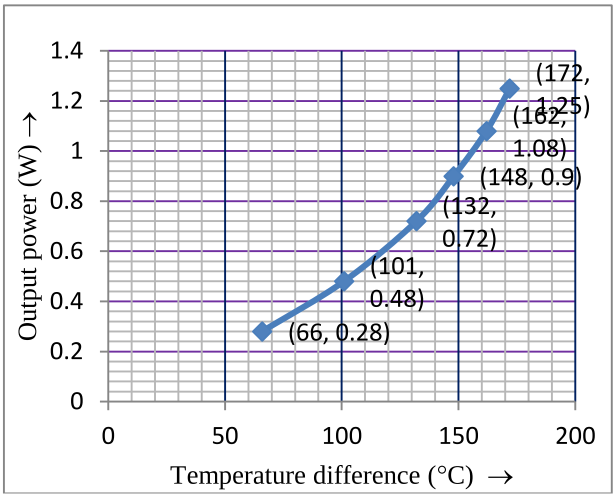

Fig.5: Output power VS temperature difference for two candles.

5. RESULTS

For single candle input

Maximum voltage, $V_{MAX} = 1.7V$

Maximum current, $I_{MAX} = 0.19A$

So, maximum output power, $P_{OUT} = 1.7V \times 0.19A = 0.32W$

For double candle input

Maximum voltage, $V_{MAX} = 2.6V$

Maximum current, $I_{MAX} = 0.48A$

So, maximum output power, $P_{OUT} = 2.6V \times 0.48A = 1.25W$

6. CONCLUSIONS

To minimize the heat loss from any heated body seebeck effect becomes efficient [5]. When temperatures of the candles are more that is the greater the temperature difference between the hot and cold junctions output power will be more. The energy is an important input to sustain industrial growth and standard of living of a country can be directly related to energy consumption. The conventional energy sources energy like coal, oil, uranium etc are depleting very fast and by the turn of the century man will have to depend upon non-conventional sources of energy for power generation. Advantages of the electricity generation by using candles such as it is less Pollution free power generation; simple construction and easy maintenance; no manual work necessary during generation; energy available all year round; no fuel transportation problem; no external source is needed for power generation; less floor area; easy to install, low budget electricity production, low initial cost & capital cost therefore project is economical. Power generation is simple and we can use Battery to store the generated. There are so many applications of this technology. Power generation using heat energy can be used in remote regions. This project is the one step to path of exploring the possibilities of energy from several non-conventional energy sources. From single candle wax we can generate 0.323W power (where output voltage and current are 1.7V and 0.19A respectively) which is sufficient to run a small DC motor or a few LEDs. By using two candles wax the output voltage, current and power are 2.6V, 0.48A and 1.25W respectively and this power is enough to run a 3V DC motor and some 3V LED connected in parallel simultaneously.

7. REFERENCES

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8. NOMENCLATURE

Symbol	**Meaning**	**Unit**
V	Voltage	(V)
P	Power	(W)
I	Current	(A)