International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-1, May 2020

A Report on Design & Setup of Peltier Module Based Air Cooler

Devjyoti Pal, Ali Ansari, Kantanu Kr. Behera

Abstract*: *With the increase in global warming levels day by day leading to the increase in average temperature throughout the year which makes people living in areas infested with load-shedding more hectic and troublesome. As the contemporary cooling method including Coolers and Air-conditioners do not work on the inverter for backup electricity purposes which make them useless as such during the peak heat hours. So, as to combat the problem with portability, economy and cost-effectiveness in mind the concept of alternative air conditioning using TEC while being used of the grid and rechargeable. While it is a common knowledge that co-efficient of performance of TEC is sub-par when compared to vapor compression air refrigeration used today but with optimized manufacturing techniques and forced convection of cold liquid increasing the effective cooling for the device and humidity controlling using moisture absorbent along with capillary tubing as thermal siphoning for heat reduction at the hot sink instead of air fin to reduce ambient heat radiation. Basically in this research we tried to increase the coefficient of performance of the Peltier Module using various techniques. The Module is also not power efficient , so in long run we can't use plenty of them either two or three also we need to create the cooling effect . So keeping everything in mind we use the module accordingly to achieve the goal and make it a model for mass production

Keywords* : *Fans , Forced Convection ,Peltier Module, TEC (Thermo-Electric Cooling)

I. INTRODUCTION

[1] In 1821, Thomas See-beck discovered that there is a continuous flow of current when two wires of different materials are joined together and heated at one end and French physicist Jean Charles Peltier module discovered Peltier effect in 1834.He found that the application of a current at an interface between two dissimilar materials results in the release of heat without using of ozone depleting chlorofluorocarbons. [2]This gave an alternative to the conventional air conditioners. The thermoelectric phenomenon has been discovered more than 150 years ago, but they are being tested to use commercially in recent decades, rectification is not possible.

1.1 Thermo-Electric Effect

Direct conversion of electric voltage to temperature differences and vice versa with the help of a thermocouple is known as thermo-electric effect. The voltage is created by thermoelectric device due to the difference in temperature on each side. Therefore, the voltage applied causes the heat transfer from one side to other creating a temperature difference. According to the scale of atom the applied temperature difference is caused by the electrons or holes they diffuse from hot side to cold side. The thermoelectric effect can used in generating electricity, for measuring temperature or it can be used in changing the temperature of the objects.[2] The thermoelectric devices are for temperature controllers because the heating and cooling depends upon the polarity of the applied voltage.

1.1.1 See-beck Effect

[3] The electricity produced in the junction of different types of wire due to conversion of heat is known as See-beck effect. In this effect the voltage and thermoelectric EMF is created due to the temperature difference of two different metals or semiconductors which causes a continuous flow of current in the conductors. The See-beck effect used in a thermocouple for measuring the temperature difference by setting one end to a known temperature. When more than one thermocouple are connected in series it is called thermopile.

1.1.2 Peltier Effect

[3] It occurs due to the presence of heating or cooling in the electrified junction of two different conductors with the change in temperature is known as Peltier effect. The effect will be stronger when two different semiconductors are used instead of conductors in the circuit.

1.1.3 Thomson Effect

[3] The absorption of heat occurs due to the passing of electric current through the circuit has a temperature difference along its length. When the heat transfer is forced on the production of heat associated with the electrical resistance to currents in the conductors.

The technology is very less frequently applied as compared to vapor–compression refrigeration. The primary advantage being lack of moving. Thus primary advantages of using a thermoelectric cooler.

(i) Less maintenance is required due to no moving parts and also doesn't use refrigerant or CFC's.
(ii) Higher degree of control of temperature by changing voltage and current.
(iii) Can be used in environment which is unsuitable for conventional methods.

Manuscript received on April 02, 2020.
Revised Manuscript received on April 20, 2020.
Manuscript published on May 30, 2020.
* Correspondence Author
Devjyoti Pal, B.Tech in Mechanical Engineering from KIIT University , Bhubaneswar , Orissa , India.Email: devjyotipal215@gmail.com
Ali Ansari, M.Tech in Structural Engineering from Integral University, Lucknow, India. E-mail: Alibinhaneef@gmail.com
Kantanu Kr. Behera, Founder of K Infotech and Engineering Services, Durgapur, India. Email: kkantanu@gmail.com

[4] A single TEC can create a temperature gradient of 70°C between its two sides. Thus, if we are able to keep the temperature of the hot side at ambient or room temperature then we will be able to generate cooling from the other side of the Peltier module.[13] In refrigeration uses, thermoelectric junction have about 1/4th efficiency of the actual Carnot cycle thus is used only in environments where solid state nature outweighs pure efficiency.

Therefore the main motivation of the project lies in the facts that:

- Reducing the carbon footprint by manufacturing a low cost, low maintenance high efficiency cooling devices.
- Creating the device to be portable so that can be used of grid to the places where conventional cooling is not a viable option.
- Creating a device that can be easily manufactured and mass produced if necessary for the poor people with low access to electricity without complicated fitments.

[4] experimental study reveals a payback period of 0.75 years comparable to 1 ton refrigeration which sounds profitable.

II.OBJECTIVE

[6] The fan takes in air from the atmosphere which goes over the cold water and looses all its moisture and heat. The water in the cold tank is cooled with the help of the Peltier module and the other side of the Peltier module gives out heat which is being trapped in the hot tank containing sand. Inside the hot tank goes a coil of copper tube through which the water is being pumped with the help of the pump.[7] The capillary tube of lesser cross- sectional than copper tube is attached at the out let of the pump so that with the help of throttling effect the temperature of the water reduces on the outlet of the pump and it again enters the hot tank. It is being done to keep the temperature of the sand in the hot tank low. The water with reduced temperature in the copper tube again takes heat from the sand in the hot tank and goes out like this way the cycle continues. And the cool air formed in the cold tank is pulled out by the other fan. The fans on the both side of the cold tank suck in air at ambient temperature from the atmosphere. To restrict the air flow in different direction and concentrate it inside the cold tank we use air ducts on both fans. Also for the full contact of air from out side and water inside the cold tank we have made two slots on both sides of the cold tank. And for getting maximum heat transfer between air and water forced convection is being used. Sand is known to have good absorber of heat so the hot tank is filled up with fine sand. Copper tube with reducing cross-sectional area is inserted inside the hot tank to maintain the temperature at the hot tank. For keeping a continuous flow of water inside the copper tube in the hit tank a 1.6m pump head is being used.

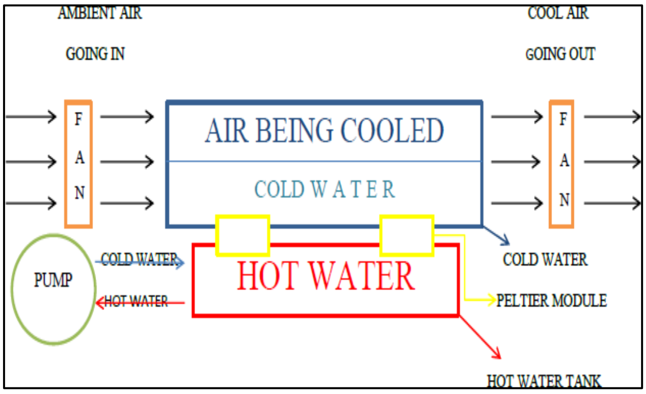

Fig 2.1:-Block Diagram of the setup

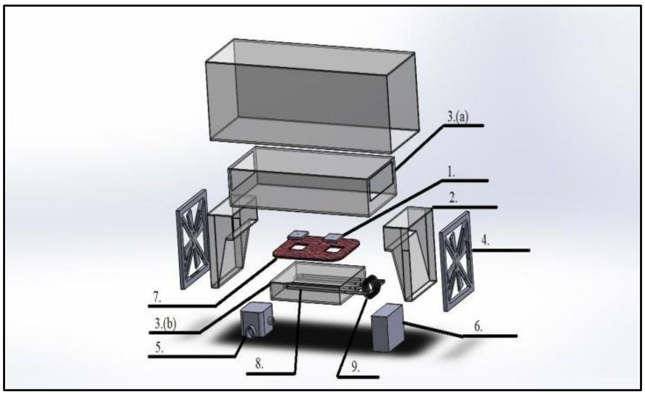

Fig: 2.2:-CAD Model of Prototype

III. Different parts of the prototype

2.1.1 Peltier Module

[6]Thermo electric cooling based on Peltier effect for creating a heat flux between two different types of materials forming a junction. An advantage of using Peltier module is lack of moving parts or circulating liquid, small size, invulnerable to leaking. Also the current consumption of the Peltier module is very less. Therefore with less current consumption it will provide effective cooling which is our main motto.

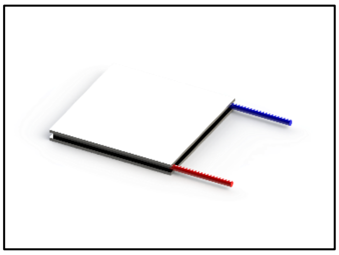

Fig 1.3: CAD Model of Peltier Module[18]

2.1.2 Air duct

A thin duct manufactured using Galvanized Iron sheet (GI sheet) of 0.5 mm thickness is been used. The GI sheet is used due to its high mach inability and flexibility. The different parts are cut out and fixed together. The have to carry the weight of the fan while it is operating. Also it should be able to direct the air completely in and out of the cold tank effective.

Retrieval Number: A3010059120/2020©BEIESP
DOI:10.35940/ijrte.A3010.059120
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

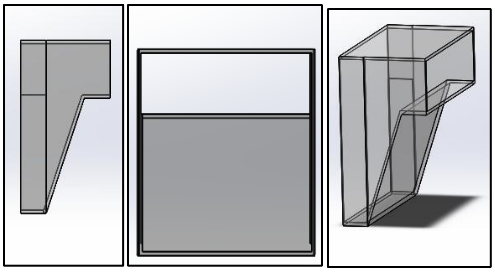

Fig 1.4: CAD Model of Side, Front & Isometric view of air duct

2.1.3Tanks

Two tanks are made one big and another one small for storing water. Bigger tank is fitted with fans and used as a cold tank. The smaller one is completely sealed and is used to store sand and is used as hot tank.

a). <u>Cold Tank</u>: This tank will be fitted with two Peltier Modules at the bottom which will reduce the temperature of the water in the tank. On both sides of the cold tank it will contain slit which would be fitted with the air ducts. On one side the fan will suck in air from the atmosphere and it will be sent over the cold water were the air will loss all its moisture and temperature into the cold water and the cold air will go out through the other side.

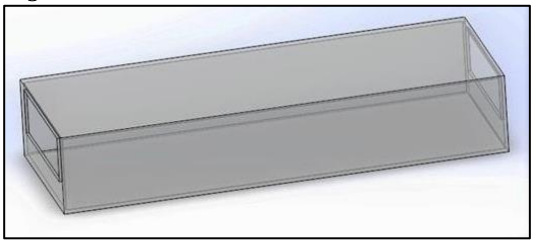

Fig 1.5: CAD Model of Cold Tank

b) <u>Hot Tank:</u> The tank will be filled up with sand and will be completely sealed so that the heat cannot escape. The sand is known to be good absorber of heat so it is being used. This tank will be placed to the other side of the two Peltier Modules. The other side of the Peltier Module will give out the heat which will be trapped into the sand in the hot tank. To keep the temperature inside the hot tank in check copper tube passes through inside the tank. The two ends of the capillary tube are fitted with the pump to keep the water circulating inside the tank. In the outlet of the pump is fitted with capillary tube whose cross-sectional area is lesser than the copper tube so that through throttling process the temperature of the water inside the capillary tube is reduced which is connected to the other end of the copper tube. When the water with lower temperature flows through the copper tube inside the hot tank and the temperature of the water being low will absorb the temperature of the sand in the hot tank acting as a thermal siphon for hot tank.

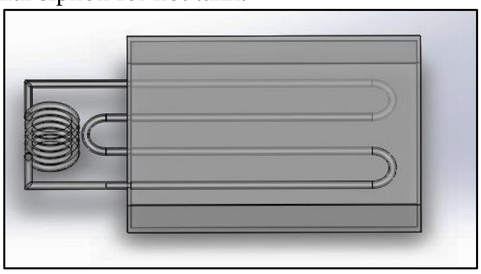

Fig 1.6: CAD Model of Hot Tank

2.1.4 Fans

Two fans of 24v DC, 1.38 amps are used. One fan which is fitted in the air duct on one side is used to draw in the outside air and sent it through the slit over the cold water in the cold tank. The other fan will suck out the air which has lost all its moisture and is now cold to the outside atmosphere.

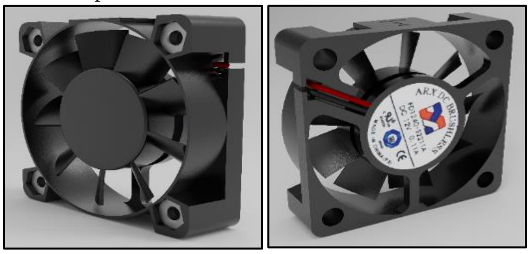

Fig 1.7: CAD Model of Fan[19]

2.1.5 Pump

A pump of 18W, head of 1.6 meters is used to pump water through copper tube and finally through the capillary tube of even smaller cross-section. At first the water will absorb heat from the sand and go out then through throttling process the temperature of the water will reduce. It will again circulate through the copper tube inside the hot tank.

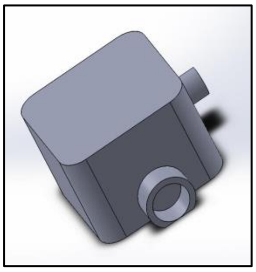

Fig 1.8: CAD Model of Pump

2.1.6 Voltage controller

Voltage controller is used to convert the fixed voltage and fixed alternating current from electrical input supply to obtain variable voltage in output delivered to a resistive load. Here we convert the 220V AC to 24V, 2A DC to run the fans.

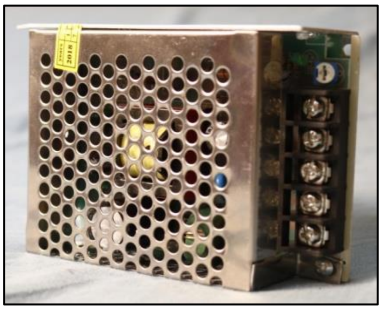

Fig 1.9: Voltage Controller

2.1.7 Insulation Plate

Wood is known to be a good insulator. So, wood is used to insulate the surface between hot and cold tank. So that heat cannot escape to other side. Wood along with glass wool is used to make a better insulation. The heat from the hot tank may reach to the cold tank and increase the temperature of the water in the cold tank. So for that reason an insulation plate is placed between the hot tank and the cold tank to create a separation and barrier to the heat from the hot tank. Wooden plate is also used to fix two Peltier Modules.

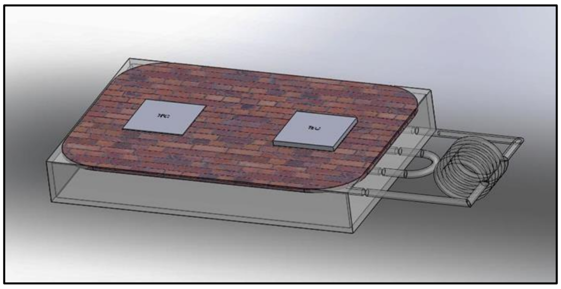

Fig 1.8:-CAD model of Hot Tank with Insulation plate

2.1.8 Copper Tube

Copper tube is used to circulate the water inside the hot tank and also take the heat from the hot sand and sent it to the pump. The cross section of the copper tube is 0.8mm and the copper is known to have better conductivity.

2.1.9 Capillary Tube

[11] Capillary tube is made up of copper of smaller cross section about 0.2mm. Water is forced to pass through the capillary tube in order to cool through sudden decrease of cross section. So, in order to overcome the resistance offered by the capillary tube the liquid is sure to lose some energy and that energy in form of heat. Thus, we can obtain cold water and can re-circulate it within the hot tank to maintain optimum temperature.

2.1.10 DC to DC Converter

The DC to DC Converter of 15W is used to run portable electronic devices. Here we are using it to run our two Peltier Modules of 6V each.

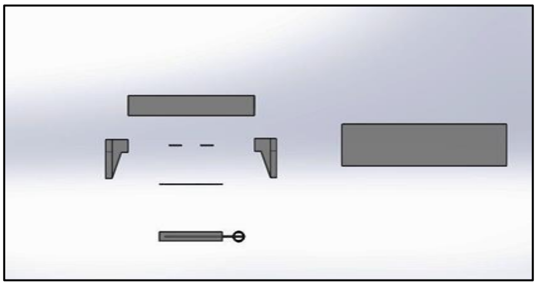

Fig 1.9: CAD MODEL Of Components Before Assembly

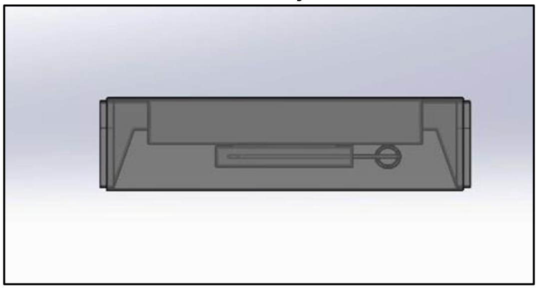

Fig 1.10: CAD MODEL of Components after assembly

Table 1.1 – List Of Components

Name Of The Element	Specifications	Quantity	Dimensions
Cold Tank	GI Sheets	1	Length- 0.4m, Breadth-0.15m, Height-0.07m Depth of water it can hold – 0.025m
Hot Tank	GI Sheets	1	Length-0.195m, Breadth-0.13m, Heigth-0.03m
Peltier Module	12V , 6A (MAX)	2	Length-0.04m, Breadth-0.04m, Height-0.004m
Fans	24v DC, 1.38 amps(brushless DC)	2	Length-0.12m, Breadth-0.12m, Width-0.038m
Centrifugal Pump	R.P.M-2200, Flow Rate-780 L/HR, INPUT: 160V-230V/50Hz.	1	Length-0.08m,Breadth-0.056m,height-0.07m
Voltage Controller	220V AC to 24V 6A DC	1	Length-0.11m, Breadth-0.075m, Heigth-0.035
Insulation Plate	Wooden plate	1	Length-0.175m, Breadth-0.1m, Heigth-0.004m
DC To DC Converter	Voltage: 4-40V, Frequency-150KHZ	1	Length-0.055m, Breadth-0.035m, Height0.01m
Air Duct	GI Sheet	2	Length-0.14m, Breadth-0.07m, Height-0.145m

III. COST OF THECOMPONENTS

3.1.1 Cooling Systems

Table 1.2: Cost of Cooling Systems

Components	Quantity/Length	Cost
Capillary tube	1 No.	Rs.50
Copper tube	4 ft.	Rs.18 /ft.
Fans	2 No.	Rs. 250 /fan
Plastic tubes	3 ft.	Rs 10 / ft.
Pump	1 No.	Rs. 250

Retrieval Number: A3010059120/2020©BEIESP
DOI:10.35940/ijrte.A3010.059120
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

3.1.2 Storage Systems

Table 1.3: Cost of Storage Systems

Components	Quantity	Cost
Cold tank	1	Rs 400
Hot tank	1	Rs 300
Fan casing	1	Rs 400

3.1.3 Peltier Module

Table 1.4: Cost of Peltier Module

Components	Quantity	Cost
Peltier module	2 in quantity	Rs 500 / module

3.1.4 Other Component

Table 1.5: Cost Of The Other Components

Components	Quantity	Cost
Voltage regulator	1	Rs 480
Battery	2	Rs 330/battery
Battery charger	1	Rs 400
Zip tag	100 piece	Rs 100
M-seals	4 packets	Rs 40
Spray paints	2 in quantity	Rs 139/paint
DC converter	1	Rs 440

IV. CALCULATION

Here model no. is -12706 , which indicates its maximum voltage 12V and maximum current 6A. These values are theoretical but in actual it is found that maximum voltage will be around 11.06 V and maximum current be 5.27A. For the sake of calculation we take the theoretical values. Therefore, we find the resistance to be 2Ω(ohm) but in actual it is around 2.1Ω. As the main motto of this research paper is to dissipate the heat to achieve the optimum cooling. So, we here only calculate the heat emission from the hot side.

$$Qem = \alpha ITh - \Delta T/\theta + .5I^2R \; []$$

For example, if we take $\Delta T = 40°C$, R=2Ω ,we get the total heat emission to be 21.33 W. As we are going to increase the temperature difference the heat emission will increase according to the equation. Hence, it is proved that the Peltier Module is efficient in lower thermal gradient. In this experimental setup , Peltier Module is attached with voltage controller whose resistance is found to be 0.24Ω when applied to 220V AC to 24V,6A DC . So, accordingly heat emission will also increase.

Table 1.6: Calculative Values

Hot Side Temperature	Cold Side Temperature	ΔT	Heat Emission (Qem)
60°C	20°C	40°C	21.33W
80°C	10°C	70°C	21.44W

Hot tank is made up of GI Sheets and sand filled , we calculate the heat transfer rate of both the material in order to get the proper arrangement . After calculating we get the heat transfer rate of sand with GI Sheet is 6.61 W. The surface area of the hot tank is found to be .025m^2 multiplied by heat conductivity of sand and GI Sheet we get the heat transfer rate.

We see that the heat transfer rate of the system is lesser than the heat emission rate of the peltier module. So to combat with this problem we apply thermal paste.

$$Q = KA(Th - Tcold)/D$$

Table1.7: Calculation After Thermal Paste Application

ΔT	Heat Emission (Qem)	Heat transfer rate(Q)
40°C	21.33 W	10.27 W
70°C	21.44 W	10.63 W

V.DESIGN OPTIMIZATION

In the previous design there was a separate cold tank and casing of fan but in the new one a combined chamber for cold tank with fan casing is to be made so that it can withstand the vibration during motion of fan and no separate joining is required and no chance of effective loosening of the joints. Apart from that a honey comb structure is to be made alongside the casing of fan to absorb the moisture of the air which increase the degree of comfort. Moreover, An outer cover is made covering the hot tank and other static components. All the electrical wiring is covered properly to avoid accidents. Proper coating of the material is needed for effective heat insulation of the hot tank. And all the electrical connections are taped to provide effective shock proof cooler in case of any emergency.

VI. FUTURE CHANGES IN MANUFACTURING

6.1 Materials

Our main aim was to build an air cooler which is both lightweight and portable so for that we choose Aluminum which would be cheaper too. During manufacturing it will be much easier to join the ends of the sheet because brazing can be done on it with accuracy. Moreover, it can carry the weight of fan and other parts like voltage regulator etc. alongside it can also withstand the wear and tear during manufacturing. As a result, both the hot and cool tank can be built with accuracy.

6.2 Manufacturing

During manufacturing the main problem was lack of equipment's so bench vice, hammer and hydraulic press would be required for the job to be done effectively with accuracy. As the shape of the tank is very important for the proper functioning of cooler. Vents had to be cut out in the cold tank for that we would require proper cutting tool which would cut in the exact dimension. Aluminum can also withstand high wear and tear during cutting of vents in the tank. Many holes of accurate dimension are needed to be drilled for which dot punch and hand drill is required.

The sheets are folded with proper bench vice and hammer such that there is no opening in the edges then the bending is done by press for accurate result. Now after the bending is done properly then silica gel along with M-seal is used in the edges to fill up any cracks or holes formed during manufacturing to prevent any leakage. no separate air duct is to be made for the fans. For that proper bending and pressing equipment's are required.

VII. CONCLUSION & FUTURE SCOPE

Thermoelectric coolers are used for removing heat from mili watts to several thousands of watts. They can be used for several purposes like small refrigeration to as large as a submarine. Although TEC's have low life, and their cooling power are measured by the change of their AC resistance. But a finding of the product thus designed showed a trend that cooling tend to decline at higher temperature suggesting loss of operationally at higher temperature. With further problem arising in manufacture a completely leak-proof environment which is close to impossible for a device with long cycle period in time thus lead to certain machining problems thus the work status of this project as of now still remains in development process due to snags in manufacturing. Following are the future scope in the project:

- Corrosion resistant material to me chosen with machinability of the material similar to aluminum sheets used.
- Need for a development of a more efficient thermal syphon for increasing the COP of the current apparatus to compensate for the loss in operationally at higher temperature.
- Higher powered COP attached with voltage regulator to augment cooling a changing the cooling temperature with the change in voltage of the system.

ACKNOWLEDGEMENT

The author would like to acknowledge Kantanu kr. Behera & Ali Ansari to provide the required technical guidance , helping out in Ansys software. Author would also like to thank the reviewers for their valuable suggestion in order to enhance the manuscript of interests regarding the publication of this paper.

REFERENCES

1. El Cosnier W., Gilles M., Lingai. "An Experimental And Numerical Study Of A Thermoelectric Air-Cooling And Air-Heating System", *International Journal Of Refrigeration*, 31, 1051 – 1062,(2008).
2. Sujin., Vora And Seetawan.,"Analyzing Of Thermoelectric Refrigerator Performance" Proceedings Of The 2nd international Science, Social-Science, *Engineering And Energy Conference*, 25,154–159,(2000).
3. Wei. Jinzhi. Jingxin & Chen.,"Theoretical And Experimental Investigation On A Thermoelectric Cooling And Heating System Driven By Solar", *Applied Energy*, 107, 89–97,(2013).
4. Maneewan., Tipsaenpromand Lertsatitthanakorn.,"Thermal Comfort Study Of A Compact Thermoelectric Air Conditioner", *Journal Of Electronic Materials*, 39(9), 1659-1664,(2010).
5. Manoj S. Raut And P. V. Walke. – "Thermoelectric Air Cooling For Cars",2012
6. Manoj Kumar., Chattopadhyay And Neogi.,"A Review On Developments Of Thermoelectric Refrigeration And Air Conditioning Systems", A Novel Potential Green Refrigeration And Air Conditioning Technology. *International Journal Of Emerging Technology And Advanced Engineering*, 38,362-367,(2013).
7. Astrain D., Vian J.G., & Domınguez M.," Increase Of COP In The Thermoelectric Refrigeration By The Optimization Of Heat Dissipation". *Applied Thermal Engineering*, 23, 2183–2200,(2003).
8. Mohammad Jafari, Hossein Afshin, Bijan Farhanieh, Atta Sojoudi,"Numerical Aerodynamic Evaluation And Noise Investigation Of A Blade Less Fan", *Journal Of Applied Fluid Mechanics*, 8, 133-142,(2015).
9. Signe Kjelstrup,"Dissipated Energy In The Aluminum Electrolysis",Hydro Aluminum Technology Center, 467-474,(1998).
10. "Thermoelectric Solar Refrigerator" By Sandip Kumar Singh, Arvind Kumar ISSN (Online):2349-6010.
11. "Heat Pump Design Using Peltier Element For Temperature Control Of The Flow Cell" By Abhinav Pathak And Vikasgoel.
12. "Experimental Development Of Two Phase Thermo Siphons And Capillary Lift Which Performed Much Better In Natural Convection" By Saket Kumar ; Ashutosh Gupta ; Gaurav Yadav ; Hemender Palsingh.
13. "Review Paper On Thermoelectric Air-Conditioner Using Peltier Modules" Benziger B, Anu Nair P & Balakrishnan P Department Of Mechanical Engineering, Regional Centre Anna University: Tirunelveliregion, Tirunelveli, Tamilnadu.
14. "Method for thermoelectric cooler utilization using Manufacturers Technical Information",Telkom University Jalan Telekomunikasi Terusan Buah Batu, Bandung, Indonesia, 40252, 020002.
15. "Effective Thermal Analysis Of Using Peltier Module For Desalination Process"
1.School Of Engineering, Cardiff University, CF24 3AA, UK
2.Faculty Of Engineering, University Of Kufa, Najaf, Iraq
16. "Performance Of A Portable Thermoelectric Water Cooling System" ahmed Al- Rubaye, Khaled Al-Farhany* And Kadhim Al-Chlaihawivolume 9, Issue 8, August 2018, Pp. 277–285, *Article Id: Ijmet_09_08_030* Available Online At Http://Www.Iaeme.Com/Ijmet/Issues.Asp?Jtype=Ijmet&Vtype=9&Itype=8 Issn Print: 0976-6340 And Issn Online: 0976-6359
17. "Specification of thermoelectric module TEC1-12706 Creative technology with fine manufacturing processes", provides you the reliable and quality products Tel:+86-791-88198288 Fax:+86-791-88198308 Email:Sales@Thermonamic.Com.Cn Website:Www.Thermonamic.Com.Cn
18. https://d2t1xqejof9utc.cloudfront.net/cads/files/23ef78abaebac95620e600b9f5406b1c/original.zip
19. https://d2t1xqejof9utc.cloudfront.net/cads/files/660600bf72baf4f166853922b2814427/original.zip

AUTHORS PROFILE

Devjyoti Pal was born in 1997 in Kolkata city , West Bengal . He has done his B.Tech (Mehanical Engineering) from KIIT University in 2019 . He is currently working as a junior CAD Engineer in CADD Centre , Hazratganj, Lucknow having an experience of about 4 months.

Ali Ansari was born in 1996 in Lucknow city, Uttar Pradesh. He is currently doing M.Tech (Structural Engineering) from Integral University, Lucknow, India. He did his B.Tech (Civil Engineering) in 2018 from Integral University, Lucknow, India. He has having more than 2year experience in CADD Centre, Hazratganj, Lucknow as a Technical leader also having 2 year experience in The Roots Incorporation as a Structural Engineer.

Kantanu Kr. Behera, was born in 1990 in Jaleshwar Baleshwar , Odisha. He has done his diploma (Mechanical Engineering) in 2009., completed his B.Tech (Mechanical Engineering) in 2014 from Biju Pattnayak University of Technology. He has a wide range of experience in teaching and research in both UG and PG level . He is the founder of K Infotech and Engineering Services with 11 years of experience in the relevant field.