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Design and Manufacturing Thermoelectric Refrigerator & comparison with Electrolux Refrigerator

Mr.P.B. Pawar[1], Mr. D.B. Jadhav[2], Mr. P.S. Mandake[3], Mr. A.S. Bodhe[4], Mr. V.B. Dixit[5]

[1,2,3,4]UG Student, Department of Mechanical Engineering, Dnyanashree Institute Of Engineering and Technology Satara
[5]Assistance Professor, Department of Mechanical Engineering, Dnyanashree Institute of Engineering & Technology Satara

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Abstract: *The global increasing demand for Refrigeration, led to production of more electricity & consequently more use of Chlorofluorocarbons which acts as contributing factor in the deflection of Ozon layer The Thermoelectric refrigeration is the new Alternative because it can translate electricity into useful cooling. Thus, thermoelectric refrigeration is greatly needed, mostly for developing countries where long life & low maintenance is needed. The main objective is comparison between Design & manufacturing working Thermoelectric Refrigerator and Electrolux Refrigerator on the basis of Coefficient of Performance. Both systems having 18 lit capacity. Our project utilizes electric energy to run thermoelectric system. Thermoelectric has various application like food preservation military purpose*

Keywords: *"Thermoelectric module Power supply component, Experimental setup"*

1. INTRODUCTION

When two dissimilar metal in junction current will pass between the junction or circuit. This phenomenon is called as Seeback effect. Peltier French watchmaker & an amateur scientist invented a reverse effect of the Seeback. He discovered that using joined dissimilar metal heat pump can made due to increasing demand for refrigeration in various sector led to production of more electricity & more release of harmful gas like co_2 all over world which is main reason of global warming on climate change. Now days Thermoelectric refrigeration is new alternative source.

The thermoelectric module is made of semiconductor material electrically connected in series configuration and thermally in parallel to create cold & hot surfaces. Although they are very light, low cost, less efficient and environmentally friendly, silent in operation and also portability in the design. When electrical current is applied in the junction then one junction become cold and another become hot because thermoelectric cooling form of solid -state refrigeration.

1.1 Working principle of TER

Peltier Effect

In a pair of dissimilar metal direct current is passed through it, there is heating at one junction and cooling at another junction. By varying current Peltier observed heating and cooling rate for different set of elements.

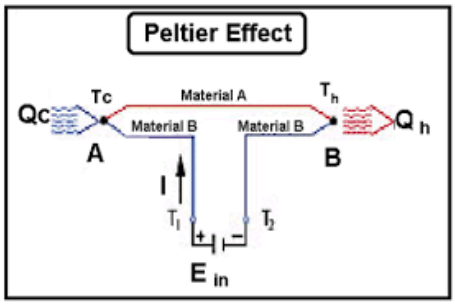

Fig 1. Peltier Effect

2. Literature Review

Min Gao et. al. [1] (1999) studied Materials, with the efficient generation of power by the See back effect or refrigerates by the Peltier effect, are known as thermoelectric materials. They are also able to act as solid-state refrigerators or heat pumps, without having any moving parts or using environmentally harmful fluids. Due to the high reliability and simplicity, they are widely extensive use, such as space power generation and a variety of cooling applications.

G. Jeffrey. Snyder Eric's [2] **(2008)** thermoelectric materials are bulk alloy materials such as Bi_2Te_3, and $CoSb_3$, among which Bi_2Te_3 is the most usually used one. They regularly process a ZT value less than one. From 1960s to 1990s, success in increasing ZT was diffident. After the mid-1990s imaginary predications recommended that thermoelectric material efficiency could be greatly enhanced through nanostructures engineering. Meanwhile, owing to the modern synthesis and characterization techniques, conventional bulk materials containing nanostructure constitutes have been

explored and found so that high efficiencies could be achieved. Thus, in currently, the advances in ZT factor came from two primary approaches: 1) bulk samples containing nanoscale constitutes

Francis et. al. [3] (2013) evaluated the performance of thermoelectric refrigerator. The research attentive on simulation of a thermoelectric refrigerator continued at 4°C. The performance of the refrigerator was simulated using MATLAB under varying working situations. The various parts of system like refrigeration chamber, thermoelectric modules, heat source and heat sink. Results show that the coefficient of performance (C.O.P) For maximum efficiency the temperature difference is to be kept to the simplest minimum.

Rowe DM Min Gao [4] (1998) There are two main application of thermoelectric, one is electricity generation with waste energy and renewable energy also evaluate thermoelectric module for power generation.

3.Electrolux Refrigeration system

3.1 Principle: Electrolux refrigeration is also called as Domestic Electrolux Refrigeration some time known as three fluid Refrigeration as it uses three fluid for the cooling process which are Ammonia, Hydrogen, water.

3.2 Construction & Working: Its work on 3 fluid system, there is no circulation pump. All pressure in the is the same throughout the system. The third fluid mainly in the evaporator thus, reducing partial pressure of refrigerant to enable to evaporate at low pressure & low temperature. Liquid NH_3 evaporates in the evaporator in the presence of hydrogen is chosen non- corrosive and insoluble in to separator. Two U-Bend provides vapor locks to prevent H_2 from getting into the high side or solution circuit. Partial pressure of Hydrogen provides the pressure difference of NH_3 between condenser and evaporator.

Table.no.1 Technical specification

Generator	Electrically Heated
Refrigerant	NH_3, H_2O, H_2
Condenser	Natural convection
Evaporator	Natural Convection
Supply	230volts, 50Hz, 1Ph
Energy Consumption	1.07 kwh per 24 hrs.

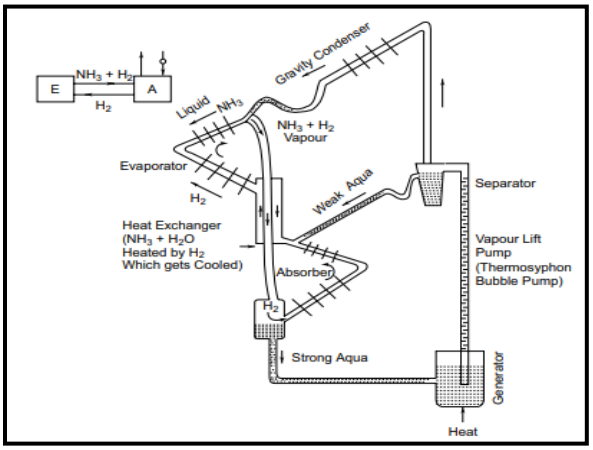

Fig 3. Electrolux Refrigeration System

Table.no. 2. Partial Pressure 0f Electrolux in (Bar)

Section	NH_3	H_2O	H_2	Total
Condenser	20.33	0	0	20.33
Evaporator	1.566	0	18.814	20.33
Evaporator	2.36	0	17.97	20.33
Generator Top	15.54	4.79	0	20.33

4. THERMOELECTRIC REFRIGERATION SYSTEM

4.1 Principle: Electric energy is applied to power input to the thermoelectric module. The cool side of the thermoelectric module is utilized for refrigeration purposes. Variously the heat from the hot side of the module is rejected to ambient surroundings by using heat sinks and fans. Thermoelectric coolers operate by the Peltier effect .

4.2 Construction & working

The cooling cabin of volume 18 lit is fabricated using wooden sheet and Thermocol. The thermoelectric module TEC1-12706 is sandwiched between two heat sink of different sizes using silicon thermal paste to set a 3 different unit. Thermal paste plays vital role in conduction of heat transfer from Peltier module to aluminum heat sinks

Peltier module assembly are placed in the cut slot with smaller heat sink facing interior of cooling cabin and larger heat sink on the outside of the cabin to establish

greater heat rejection. Electrical connections are made and power 12volt dc supplied to cabin, temperature indicator is Made for taking reading. Experiments are conducted to analysis the cop of Thermoelectric refrigerator and compare with Electrolux refrigerator. Power supply is given to the system and reading of temperature are taken by placing the thermocouple near Peltier module which is placed in cooling cabin

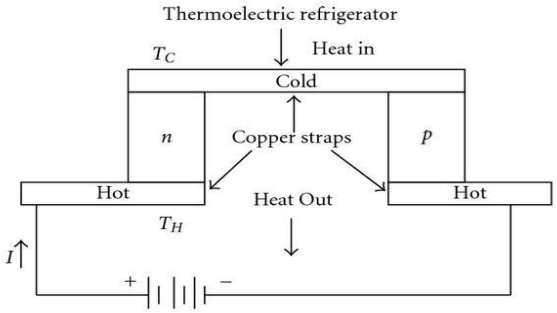

Fig 3. Schematic diagram Thermoelectric refrigerator

5. Design and Development

Design and development discuss the different parameters used to design thermoelectric refrigerator system.

A. Cooling cabin Design: volume of cooling cabin of Thermoelectric refrigeration system **is 18 litres.**
we have formula in mechanics,
1 m^3 = 1000 litre
We get capacity of refrigerator is 0.018 m^3
For 0.018 m^3, Length, (L) = 0.3m =300 mm, Width, (b) = 0.2m = 200 mm, Height, (h) = 0.3m = 300 mm

B. Cabin casing Material: Inside cabin Material is Thermocol, Outside cabin is insulated with wooden sheet of thickness 8mm because thermal conductivity of wooden is very low. Easy to manufacture

B. Selection of Thermoelectric module Cooling module are selected on the basis of heat removal from the cooling cabinet. Active load is the heat dissipated by the mass being cooled. The modules (TEC1-12706) have been used to reduce inside temperature of refrigeration space.

Table no.2. Fig. Merit of Different Material

Sr.no	Materials	Fig.Merit
1	Pb-Te_3	0.0012
2	Pb-se	0.0012
3	Pb_2—Te_3	0.0012
4	Bi_2-Te_3	0.0013

The thermoelectric cooler module material chosen is Bismuth telluride (Pb-$Te_{3)}$, Seeback coefficient **(α)** = 0.01229 V/k, Module thermal conductance (K_m)= 0.1815 W/k, Module resistance (R_m) = 0.344 *ohm*
Select a TEC1-12706 Peltier module from manufacturing data sheet as given as below, Table no.3. Data sheet for TEC1-12706

Hot side temperature	31
Q_{max}	50 watts
Δ_{max}	66
I_{max}	6.4 A
V_{max}	14.4 V
Module Resistance	1.98
Size of Module	40*40*5

C) selection of Component

1. **Peltier Device:** Thermoelectric device is pair of two dissimilar metal semiconductors or conductor with semiconductor. In this system the device is made of extrinsic semiconductor having p-n junction in series with no. of cells. The energy difference of conduction band of material should be high for higher refrigeration.

Fig 4. Peltier module

2.Heat sink: It moves the warmth produced by the electronic mechanical gadgets to the liquid medium from where the warmth is disseminated out of the framework. Warmth sink which ingests some measure of warmth from framework without changing temperature.

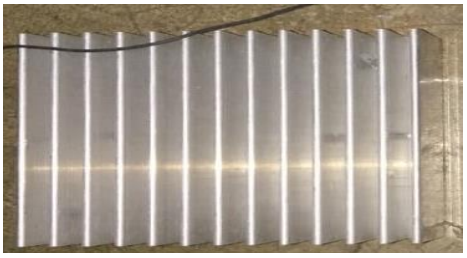

Fig.5. Heat Sink

3.Power Supply: Circuit controller is mounted on the top side of box. Circuit controller used as power supply. Both fans and Peltier module are attached to the circuit controller with the help wire. Here we have used 12V DC power supply.

Fig 6. Power supply

4. Temperature Indicator: The Temperature indicator is device that is used to measure inside temperature of cooling chamber. Probe inserted inside in cooling cabin, sense temperature insides, gives temperature data to the output display. It is an important device which is gives us the information about cooling rate of the cabin and it also helps us to calculate the efficiency of the device.

Fig 7. Temperature Indicator

5. DC Fan: This DC Fan used for throwing heat from Peltier module to increase the efficiency of refrigeration effect. It is used because one side other than cooling side get heated which needs to be cooled down. To cool the side the fan is uses to throw heat to the environment.

Fig 8. cooling fan

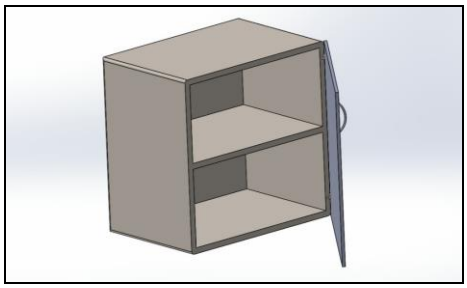

Fig 9. solid work Thermoelectric Refrigerator

6. EXPERIMENTATION & ANALYSIS

6.1. Electrolux Refrigerator

Observation for Electrolux Refrigerator
Load output: 120 volts, 90 milli Ampere
Input Generator Supply: 250 volts, 340 milli Ampere
Temperature (□) in various devices:

1. Generator (T_1) = 103°C
2. Condenser (T_2) = 40 °C
3. Evaporator (T_3) = -7°C
4. Absorber (T_4) = 32°C
5. Average Cabinet (T_5) = 18 °C

Refrigeration Effect (n) = Load (output) = V×I
n = 120 x 90 x 10^{-3} =10.6W

Generator Input (q) = V×I = 250 x 340 x 10^{-3}.

(Coefficient of performance) $_{actual}$ = n/q

$(COP)_{actual}$ = 0.1271

6.2 Thermoelectric Refrigerator

$Q_c = \frac{m\, c_p\, \Delta T}{t}$, where m= 18 kg
Cp = sp. Heat = 4.814 KJ/Kg. k,
ΔT =temp diff. between hot side & cold side =12°C
Time (t) = 1 hr,5 min
T_h = Hot side Temperature = 31+273 = 304 K
T_c = Cold side Temperature = 19=273 = 292K
Work=Voltage× Current of Peltier module× Num of Module

W = 14.4×6.4×3 = 276.48 KJ
Actual coefficient of performance = Q_C/w

$$(Cop)_{actual} = \frac{18\times4184\times12}{3900\times276.48}$$

$(Cop)_{actual}$ = 0.83

6.3 Fabricated Setup of Thermoelectric Refrigerator

Fig 10. Refrigeration body after fabrication

7. CONCLUSION

We successful designed a system that fulfils the proposed goals. It seems that, the actual coefficient of performance of thermoelectric refrigeration system is greater than actual cop of Electrolux refrigeration system. however, it is understood that present design can be used only for maintaining particular temperature. Thermoelectric refrigeration is one of the key areas where researches have a powerful interest. Moreover, recent improvement in organic molecules as a thermoelectric material capacity a bright future for TER. Thermoelectric refrigeration is gaining more attention as an affordable, reliable, and a green refrigeration alternative.

8. REFRENCES

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