Theoretical Investigation of Peltier Refrigeration Box Used For "Heating and Cooling"

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Abstract - Increasing refrigeration demand in medical field we need a portable and nontoxic refrigeration box is needed also achieve this goal refrigeration system have operating stability and size minimization. Thermo electric couple (TEC) dose best in it compare with traditional cooler devices such as compressors and heat pipes. This paper aim to obtaining the optimal cooling performance of the thermo electric refrigeration box. Theoretical analysis was develop, so to demonstrate appropriate electrical voltage range for electric components. Refrigeration demands increasing continuously in the field of air conditioning, food preservation, medical service, vaccine storage, thermoelectric refrigeration system consume less electricity than other refrigeration system and consequently decrease in CO2 concentration in atmosphere which leads to global warming and many climate changes. Thermoelectric refrigeration is a new alternative, because it can reduce the use of electricity to produce cooling effect. It also helps to achieve today's energy challenges. Thermoelectric refrigeration system have long life and low maintenance.

Keywords: *thermoelectric refrigeration; coefficient of performance; experimental investigation*

I. Introduction

Over the past years ice bottles are use for insulating materials to produce insulation box in India. Glass liner and ice bottle is cylindrical and easily broken but its storage space is limited. It is inconvenient to carry medical equipments (insulin, drugs). Thermoelectric modules made of semiconductor material electrically connected in series and thermally in parallel to generate cold and hot junctions (surface). Although they are less efficient than vapour compression system but this is very light in weight, low in cost, silent in operation and environment friendly.

The objectives of this project are to design and developed a working thermoelectric refrigerator that utilizes the peltier effect for refrigeration and maintain temperature between 20-60^{0}C. Theoretical analysis of the refrigeration system have been conducted. Theoretical calculation was conducted based on this system for optimal analysis of cooling performance. Shen et al. presented theoretical module in evaluating and optimizing coolers. However they does not consider fan for convection of heat through TEC plate. So we are adding fans for heat dissipation, so cooling rate is increase.

As a result the analysis can provide a theoretical reference for the application of refrigeration box in medical service, and be helpful to achieve aim of saving energy and improving economic efficiency.

A.Objective of project

The main objective of this research is to developed a refrigeration system with a capacity of 30L of a cooling chamber and heating chamber. System is design with a capability of maintaining the temperature of materials between 9 ^{0}C to 28 ^{0}C for a long duration. Hence the system has to be use in areas where electric power is scare, alternative source of energy like battery or solar power has to be use as optional for electricity. Moreover the system is meant for outdoor use, so it has better insulation and radiation control mandatory.

B. Problem Statements

India is the second most populous country in the world with over 1.21billion people (estimated for April, 2011), more than sixth of the world's population. India is projected to be world's most populous country by 2025.The above data shows that, as the population increase the no. of consumer of energy also increases. Conventional refrigeration systems are high energy consuming system also followings are some demerits of that system.

- Costly
- More space consuming
- Works only on ac supply
- Highly dependent on electricity supply.
- Works on CFC based refrigerant which will cause increase in the CO2 gases which is leads to global warming and many climate changes.

C. Thermoelectric Cooling Module

There are several methods which can be employed to facilitate the transfer of heat from the surface of the thermoelectric to the surrounding. Electrons can travel freely in the copper conductors but not so freely in the semiconductor. As the electrons leave the copper and enter the hot-side of the p-type, they must fill a "hole" in order to move through the p-type. When the electrons fill a hole, they drop down to a lower energy level and release heat in the process. Then, as the electrons move from the p-type into the copper conductor on the cold side, the electrons are bumped back to a higher energy level and absorb heat in the process. Next, the electrons move freely through the copper until they reach the cold side of the n-type semiconductor. When the electrons move into the n-type, they must bump up an energy level in order to move through the semiconductor. Heat is absorbed when this occurs. Finally, when the electrons leave the hot-side of the n-type, they can move freely in the copper. To increase heat transport, several p type or n type thermoelectric (TE) components can be hooked up in parallel.

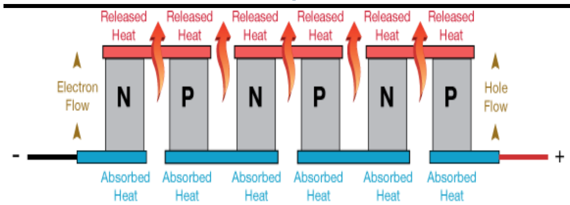
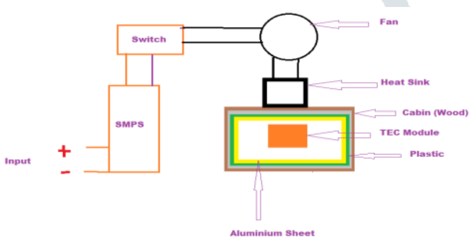


Fig. Thermoelectric module assembly

D. Literature Review:

By the study of patented thermoelectric refrigerator designs , Seebeck effect invented by Thomas John Seebeck introduce in 1821 was "phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between two substances". Peltier effect proposed by Jean Charles Athanase in 1834 was " an effect whereby heat is given out or absorbed when an electric current passes across a junction between two materials". Lenz invent a concept in 1834, "by changing the electric supply between semiconductor, then Hot and Cold side change.

E. Block Diagram of project:



F. Design procedure:

Geometry-
Rectangular box with insulation sandwiched between walls having dimensions 145*145 mm

Material-
Plywood with thermal conductivity 0.13 W/m 0K (outer wall thickness 10mm)
Insulation slag of thermocol with 6mm thickness.
K=0.033 W/m 0K
Plastic k= 0.2W/m0k Thickness 0.3mm

Heat load calculation-
1) Active heat load: Load which actually Produces heat, ex: electronic circuit like SMPS in this project there is no any active heat load hence this term is neglected.

2) Passive heat load=cooling capacity of refrigerator it is denoted by Q(conductive + convective heat transfer component
$Q=\Delta T*A/(1/h+L/k)$

Temperature to be maintain inside the cabin = 9 ^{0}C
Ambient temperature = 28 ^{0}C
ΔT = 28-9 =190C
Area = 0.145*0.130=0.018m2
$Q = \Delta T*A/2*(1/hair+L1/kth+L2/Kp)$
Q = 0.9 watt
Passive load through walls Qp=(Q1+Q2+Q3)*2=5.4W
Infiltration load due to opening and closing of door Qc = 5w
Qtp=Qp+Qc=10.4W for safety Qtp=15W

Hence module TEC1-12706 with voltage value 12V has been selected and the cooling power is 60W.
Capacity=length*width*height
=30*20*50
=30000 cm^3
Capacity=30000/1000
=30 lit.

G. Advantages:

- These are environment friendly. (No C.F.C)
- Have no vibrations and noise
- It is portable, small in size.
- Low/ no maintenance
- Works on both AC and DC supply.
- Use for multipurpose like cooling and heating

H. Disadvantages:
- Comparatively low COP
- Limited application

I. Application:
- For preservation of insulin and other drugs.
- For preservation of food stuffs.
- For cold water.
- For beverages.
- Used for domestic application

K. Conclusion
We have been successful in theoretical analysis of the system that fulfils the proposed goals. However we do realize the limitations of this system. The present research can be used only for light heat load to lower and its temperature to a particular temperature. The system is unable to handle fluctuations in load. Extensive modifications need to be incorporated before it can be released for efficient field use. This refrigeration system can be use for remote rural places where there is no electric supply.

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