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RESEARCH ARTICLE OPEN ACCESS

DESIGN AND FABRICATION OF THERMOELECTRIC REFRIGERATION SYSTEM

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Abstract:

The global increasing demand for refrigeration led to production of more electricity and consequently more release of CO2 all over the world which is a contributing factor of global warming. Thermoelectric refrigeration is an alternative as it convert waste electricity into useful cooling. Thermoelectric refrigeration is greatly required, particularly for developing countries where long life and low maintenance are needed. The objectives of this study is to style and develop an operating thermoelectrical white goods interior cooling volume of 10L that utilizes the Peltier result to keep up a specific temperature from 5 °C to 25 °C. The design needs area unit to chill this volume to temperature at intervals a fundamental quantity of half-dozen hrs and supply retention of a minimum of next half hour. The design demand, choices offered and also the final style of thermoelectrical white goods for application area unit given.

Keywords - **Global warming,thermoelectric refrigeration, Peltier effect.**

I. INTRODUCTION

Refrigeration may be a method of removing heat from a low-temperature reservoir. The increasing demand for refrigeration in numerous fields junction rectifier to production of additional electricity and consequently additional unleash of harmful gas like dioxide everywhere the globe that is a contributing factor of global warming on climate change. Thermoelectric refrigeration is a new alternative method. The thermoelectric modules are made of semiconductor materials electrically connected in series configuration and thermally in parallel to create cold and hot surfaces. Although they're less economical than the vapour compression system, they're flare, low in price, silent operational, and square measure environmentally friendly.

II. LITERATURE SURVEY

In Renewable Energy 34 (2009) article, all the components are connected together to test the operation of the thermoelectric module. The lower surface of the thermoelectric module is the hot side of the module, while the other side is the cold side of the thermoelectric module. The cold aspect of the module is required to be set in the box and the hot aspect to be set outside. The temperatures of the thermoelectrical module were measured by thermocouple junction wires that were connected to the edges of the module.The thermocouple junction was connected to a data-logger so the current was recorded in temperature units. The hot aspect of the thermoelectrical module was hooked up to the Heat-sink. Thermoelectric devices are used in power generation and cooling applications to either convert heat into electricity or to pump heat.

III. WORKING PRINCIPLE

The thermoelectrical effect is a direct conversion of temperature variations to electrical voltage and also vice-versa. A thermoelectrical device creates a voltage once there's a distinct temperature on either side. Conversely once a voltage is applied, it creates a temperature variation. Thermoelectric couples are devices capable of generating electric power from a temperature change, known to be Seebeck effect, or changing electricity into a temperature gradient, known as Peltier effect. A typical thermoelectrical module consists of 2 ceramic substrates that act as a housing and electrical insulation for P and N-type parts between the substrates. Heat is absorbed at the cold junction by electrons as they pass from an occasional energy within the p-type part, to the next energy state within the n-type part. A module contains several P-N couples that are connected electrically in series and thermally in parallel.

IV. METHODOLOGY

The method by which the project is done is explained in a detailed manner. In this work, a portable thermoelectric refrigeration unit was fabricated and tested. The general layout of the configuration is prepared and the methods of joining the individual components are selected. Improvement in the COP of 0.7 from our project is possible through improving module performance, thermal interfaces and heat sinks. The analysis done in this project ignores a lot of physics as explained in the assumption of the ideal equations. The detailed drawing is generated and is assembled properly.

V. COMPONENTS REQUIRED

A. Thermoelectric module

ThermoelectricorPeltier Cooling (TEC) Modulesin a variety of types & sizesused for cooling and also used for heating by reversing the electrical current flow and power generation.

The red wire of the thermoelectric module was connected with the positive power supply and the black wire of the module was connected with the negative power supply. Due to this method of wire connection, the lower surface of the thermoelectric module became the hot side of the module, while the other side became the cold side of the thermoelectric module.

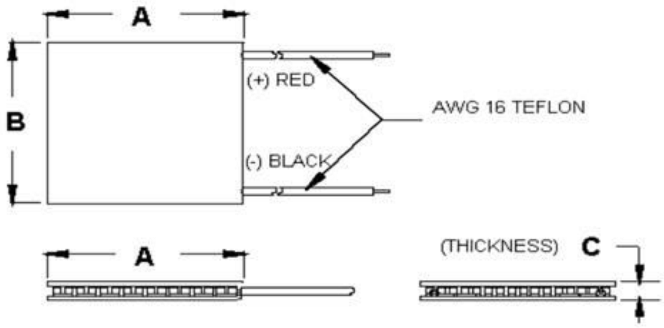

Fig.1. Thermoelectric Module

B. Heat sink and cooler fan

A heat sink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device into a coolant fluid in motion. Then-transferred heat leaves the device with the fluid in motion, therefore allowing the regulation of the device temperature at physically feasible levels.

A sink is meant to maximise its area connected with the cooling medium encompassing it. Air rate, choice of material, design and surface treatment are factors that affect the performance of a heat sink.

C. AC to DC Converter

AC to DC converter is a device which converts the input alternating current to direct current to act as power supplies for devices which use dc as operating source. In this project we need to use dc to power the TEC module and the fans used to transfer heat and cold air.

For this project we choose a power supply drive (ac to dc convertor) of the below description:

- input Voltage: AC 90 - 264V 50 / 60Hz
- Output Voltage: 12V DC, 10A, and 120W
- 100% Full Load Burn-in Test
- MTBF: 50,000 hours

D. Insulation cabin

For a refrigerator, a perfectly sealed insulating cabin is required for trapping the cooling effectof the refrigeration. So for this project a thermocol box of 10L capacity is used.

Specification: 36*13.5*20.5cm

E. Thermal Paste

Thermal paste may be a substance accustomed promote higher heat physical phenomenon between 2 surfaces and is often used between a microchip and a sink.

VI. MODEL DESIGN

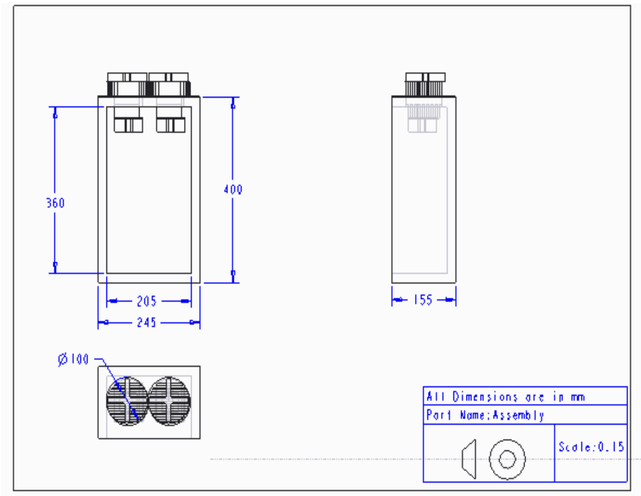

Fig.2. 2D PARAMENTRIC VIEW

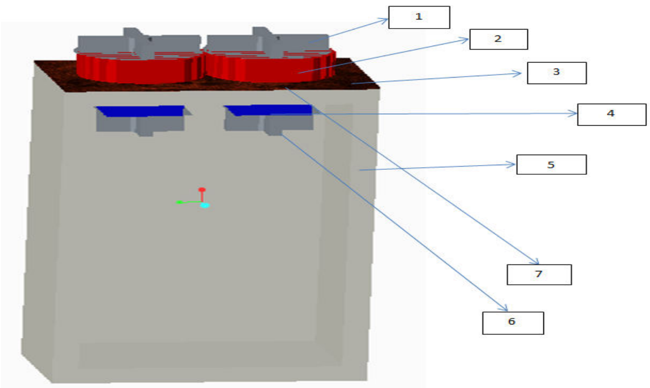

Fig.3. CAD 3D Model

TABLE I BILL OF MATERIAL

S.no	Part Name	Material	Quantity
1	Hot side fan	Plastic	2
2	Heat sink	Aluminium	2
3	Housing	Plywood	1
4	Cold sink	Aluminium	2
5	Cabin	Thermocol	1
6	Cold side fan	Plastic	2
7	TEC module	Ceramics	2

VII. FABRICATION PROCESS

To house the thermoelectric module and heat sink in place on surface of the thermocol a piece of plywood of thickness 3mm is used. The thickness of the plywood is selected as thickness of the module 3.5mm.

So a piece of plywood of specification (24*15*3) is cut out of the sheet of plywood with help of a hand saw. Further two square holes of size (4*4cm) cut out using a hand saw .The square holes are 3cm from the center on plywood sheet.

Here to paste the heat sink andthermoelectric module, thermal paste is used. This is used not only to paste the sink and module but also to improve conduction between the sink and module.

The paste is applied on both side of the module properly so both heat and cold sink are pasted to the surface of the module which is housed inside the plywood. Then the sinks were tied with steel wire in order to hold the sink in position.

VIII. PHOTOGRAPH OF THE PROJECT

Fig.4. PROJECT'S PHOTOGRAPH

IX. EXPERIMENTATION

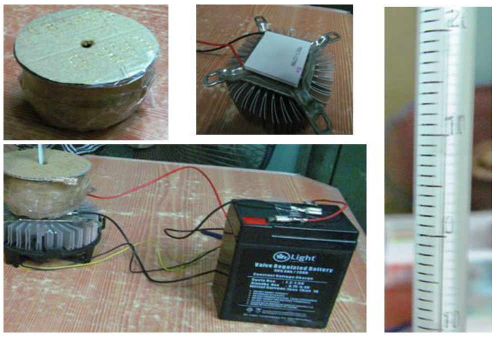

Fig.5. TESTING OF MODULE

The active heat load is expressed as the equivalent cooling power that the unit will need to provide when the sample at ambient temperature is placed in the container. It was decided that two litre of water at room temperature as the test sample.When the designed thermoelectric refrigerator was tested, it was found that the inner temperature of the refrigeration area was reduced from 33 ˚C to 13 ˚C in approximately 400 min. Coefficient of performance (COP) was determined. Water is used in place of vacuum for taking measurements and calculation. With the Experimentation, Temperature was noted with respect to the time.

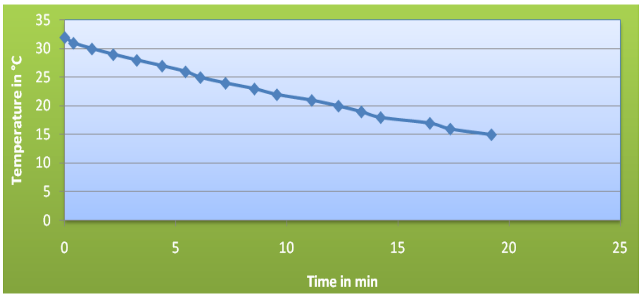

Fig.6. TIME VS TEMPERATURE GRAPH

X. CALCULATIONS

In these calculations, the properties of water are (density = 1 kg/L and CP = 4187 J/kg). Coefficient of performance (COP) of the refrigerator was calculated,

COP = Q cooling / Win **(1)**

$Q = mCp\Delta T$ (2)

Mass of water, m = density x volume = 2 kg

Total heat removed from the water = 167480 J

Q cooling = Q / Δ T = 167480 / (400*60) = 6.98w

Power given to the system for working,

W = V X I + fan power

= (12x5) + 3

= 65 W

Coefficient of performance of this refrigeration system is

Given by, **COP = Q cooling / W in**

= 6.98 / 63 = 0.120020

XI. CONCLUSIONS

The thermoelectric refrigerator serves as a very environmentally friendly product. Here, there will be reduced vibration or noise because of the difference in the mechanics of the system. Government and private sector aids that can be sought to make this system economically manufactured. Financial and marketing strategy can be adopted for the familiarization of the product. Nevertheless, a commercial thermoelectric refrigerator would be made with an acceptable performance through some improvements. We were provided with immense knowledge over designing the system for the proper functioning; we also learnt the various other processes that are used in refrigeration systems. Thus we were able to design and fabricated a portable thermoelectric air conditioner through the opportunity given to us in this semester.

XII. FUTURE SCOPE

Work is often done to enhance the material property. One example of a better ceramic material is aluminium Nitride with a thermal conductivity of 180W/m*K while the ceramic used in this work is aluminium oxide that has a thermal conductivity of 27W/m*K. This study can be extended to a system with number of modules. An application can be cited in thermoelectric air conditioning system that used more than one module. This is an expensive experiment and hence can be simulated using ANSYS to get similar results. This kind of simulation however requires a high end work station that comes with a full version of ANSYS.

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