Visvesvaraya Technological University, Belagavi

A Mini Project report on

"Solar and Peltier Based Compact Refrigerator"

Submitted in partial fulfilment of the requirements for the award of

BACHELOR OF ENGINEERING in **MECHANICAL ENGINEERING**

Submitted by:

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DEPARTMENT OF MECHANICAL ENGINEERING

CERTIFICATE

This is to certify that Mr. Shashank BB, Mr. Skanda Sharma HV, Mr. Suprith MS and Mr. Surya SR bearing USN: 4VV19ME115, 4VV19ME121, 4VV19ME135 and 4VV20ME441 respectively have satisfactorily submitted the mini project "Solar and Peltier based compact Refrigerator" as prescribed by "Visvesvaraya Technological University", Belagavi. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report. The mini-project report has been approved as it satisfies the academic requirements in respect of mini-project work prescribed for the Bachelor of Engineering Degree.

Prof. Amruth E	Dr. G V Naveen Prakash
Project Guide	Head of Department

EXTERNAL EXAMINERS

Name of the examiners	Signature
1.	
2.	

DECLARATION

We the members of the project team, studying in the VI semester of Mechanical Engineering, Vidyavardhaka College of Engineering, hereby declare that the entire project entitled "**Solar and Peltier Based Compact Refrigerator**" has been carried out by us independently under the guidance of **Prof. Amruth E**, Department of Mechanical Engineering, Vidyavardhaka College of Engineering. This project work is submitted to the Visvesvaraya Technological University, Belagavi, in partial fulfilment of the requirement for the award of the degree of Bachelor of Engineering in Mechanical Engineering during the academic year 2020-2021.

This project work has not been submitted previously for the award of any other degree or diploma to any other institution or university.

Date:

Place: Mysuru

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Abstract

We designed and constructed a *"Solar and Peltier Based Compact Refrigerator"*, with an interior cooling volume of 307 cubic centimeters (40*32*24). The refrigerator was equipped with a solar panel and on/off control which was found to be adequate to meet the required precision of 15 degrees Celsius put forth in project requirements. One liter of water was placed inside the refrigerator to test the performance of the device. We tested the maximum performance of the device by cooling a sample down from 30 degrees Celsius to 15 degrees Celsius. This project's aim is to provide small cold storage for off-grid areas.

List of Figures

List of Tables

CONTENTS

Chapter 1

Introduction

Conventional cooling systems such as those used in refrigerators utilize a compressor and a working fluid to transfer heat. Thermal energy is absorbed and released as the working fluid undergoes expansion and compression and changes phase from liquid to vapor and back respectively. Semiconductor thermoelectric coolers (also known as Peltier coolers) offer several advantages over conventional systems. They are entirely solid-state devices, with no moving parts; this makes them rugged, reliable, and quiet. They use no ozone-depleting chlorofluorocarbons, potentially offering a more environmentally responsible alternative to conventional refrigeration. They can be extremely compact, much more so than compressor-based systems. However, the efficiency is low compared to conventional refrigerators. Thus, they are used in niche applications where their unique advantages outweigh their low efficiency. In addition to this solar energy used to drive the refrigerator by using solar panel which is connected to a battery. Here the refrigerator can also run through battery when there is a cloudy climate and on a sunny day the battery is charged and the refrigerator can run continuously with continuous supply of electric current. Peltier coolers generally used in applications where small size is needed and cooling demands are not too great. The objective of this study is design and develop a working of solar and peltier based refrigerator cooling volume of that utilizes the Peltier effect and solar energy to refrigerate and maintain a selected temperature from degree Celsius to degree Celsius. The design requirements are to cool this volume to temperature within a certain time period. The design requirement, options available and the final design of refrigerator for application are presented.

1.2 Problem Statement

- Generally we see that refrigeration process uses electric energy which is not available at most of the remote places in our country.

- We know that sun energy is available everywhere which also green energy and renewable energy source. We also save electric energy here.

- The basic idea is implementation of photovoltaic driven refrigerating system powered from direct current source or solar panel (when needed) with a battery bank.

1.3 Objective

- To design and develop a thermoelectric refrigerator in order to produce a small quantity of refrigerating effect by using solar energy.
- To design a refrigerating unit that will work without any moving parts.

1.4 Scope of the Project

- Use of solar Energy: In this project we use solar panel to use sun energy and avoid the use of electric energy which cost us. So by the use of solar energy we save electric energy.
- Environment Friendly: Generally we see that common refrigerators produce CFCs which harms the environment but peltier module does not produce any harmful gases.

Chapter 2

Literature Survey

1. Sujith G. et al.(2016) In this paper author design and fabricated the Thermoelectrical Refrigeration to cool a volume of 40L using principle of Peltier effect to cool and maintain temperature range of 5°C to 25°C and the project is used only for light heat load to lower its temperature to particular temperature. One of the advantage of this project is it takes low power to drive the refrigerator.

2. Bharat M. Jibhakate et al.(2016) The study show that a Thermoelectric Refrigeration model is design and fabricated in place of compressor and it is based on principle of Peltier effect to maintain effectiveness of both heating and cooling side also the simulation is done to on thermoelectric refrigeration to maintain it at 40°C. The designed is environmental friendly also it has various applications in medical and pharmaceutical equipments.

3. Sivakumar.N.et al. (2018) In the literature the author designed the Thermoelectric Refrigeration in place of prime movers, compressor or any type of refrigerant as this designed is applicable in such areas where the electricity not available and also environmental friendly as CFC, CO_2 etc. produce in other refrigeration system. As per the experimental result on thermoelectric refrigeration the minimum temperature 15°C for cooling and maximum temperature 65°C for heating was obtained. Also comparisons of results done on effect of cooling on AC and DC supply and COP of systems.

4. Matthieu Cosnier et.Al.[2008] presented an experimental and numerical study of a thermoelectric air-cooling and air-heating system. They have reached a cooling power of 50W per module, with a COP between 1 .5 and 2, by supplying an electrical intensity of 4A and maintaining the 5°C temperature difference between the hot and cold sides.

Chapter 3

Methodology

3.1 Theory of Peltier module and Solar Energy.

3.1.1 Peltier History

Early 19^{th} century scientists, Thomas Seebeck and Jean Peltier, first discovered the phenomena that are the basis for found that if you placed a temperature gradient across the junctions of two dissimilar conductors, electrical current would flow. Peltier, on the other hand, learned that passing electric current through two dissimilar electrical conductors, caused heat to be either emitted or absorbed at the junction of the materials. It was only after mid-20^{th} century advancements in semiconductor technology, however, that practical applications for thermoelectric devices became feasible. With modern techniques, we can produce thermos electric efficient solid state heat-pumping for both cooling and heating; many of these units can also be used to generate DC power at reduced efficiency. New and often elegant uses for thermo-electrics continue to be developed each day.

3.1.2 Peltier Structure

A typical peltier module consists of an array of Bismuth Telluride semiconductor pellets that have been carrier-either positive or negative-carriers the majority of current. The pairs of P/N pellets are configured so that they are connected electrically in series, but thermally in parallel. Metalized ceramic substrates provide the platform for the pellets and the small conductive tabs that connect them.

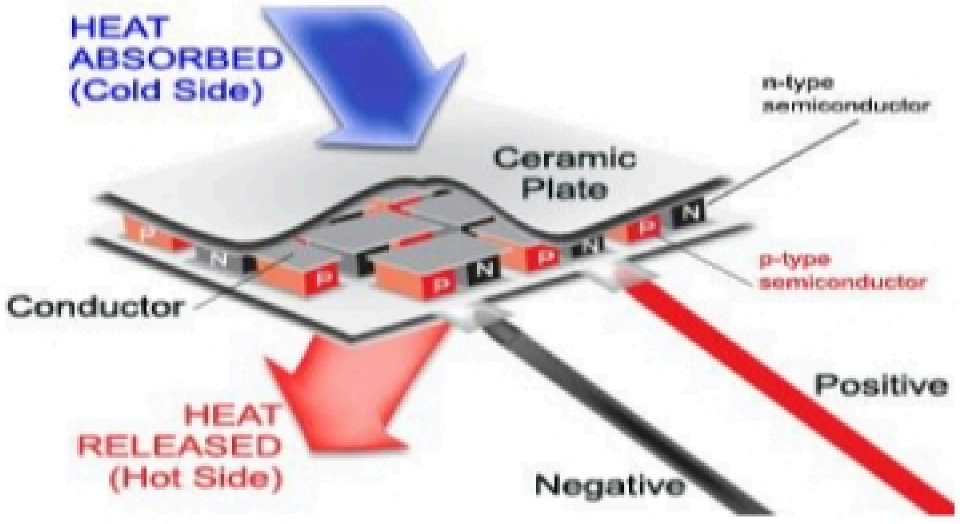

Fig 3.1.2 Structure of Peltier Module

3.1.3 Peltier Theory

When DC voltage is applied to the module, the positive and negative charge carriers in the pellet array absorb heat energy from one substrate surface and release it to another substrate at the opposite side.

The surface where heat energy is absorbed becomes cold; the opposite surface where heat energy is released becomes hot. Reversing the polarity will result in reversed hot and cold sides.

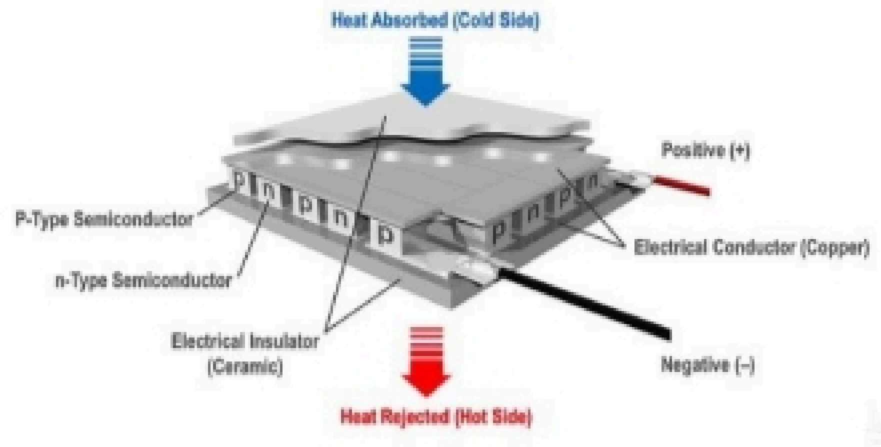

Fig 3.1.3 Peltier Theory

3.1.4 Basic Principles

When a p type semiconductor (doped with holes) is used instead, the holes move in different opposite the current flow. The heat is also transported in a direction opposite the current flow and in the direction of the holes. Essentially, the charge carriers dictate the direction of heat flow.

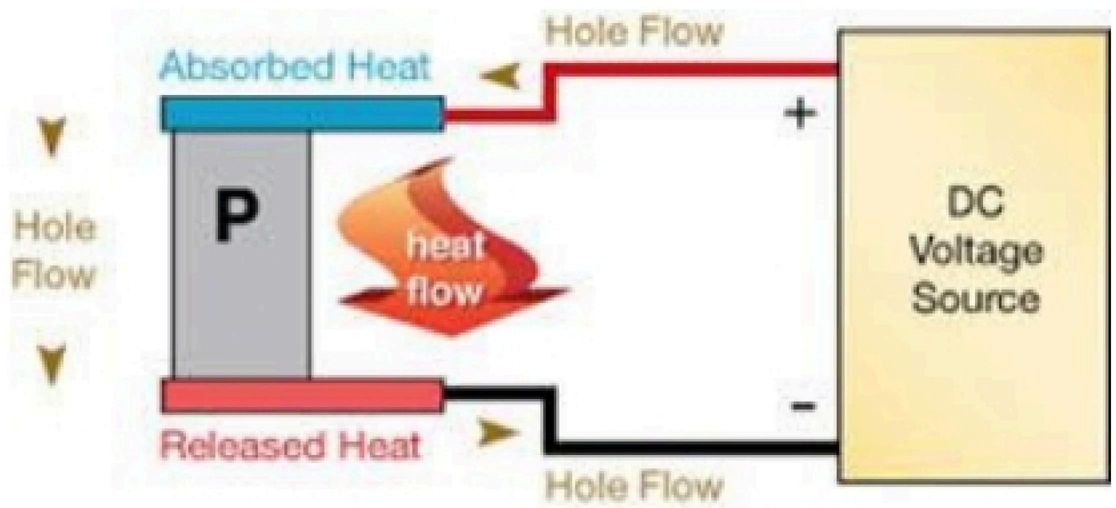

Fig 3.1.4 The basic principle of Peltier module

3.1.5 Heat Transportation

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 lower energy level and release heat in process.
- Then, as the electrons move from 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 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. They drop down to lower energy level and release heat in the process.

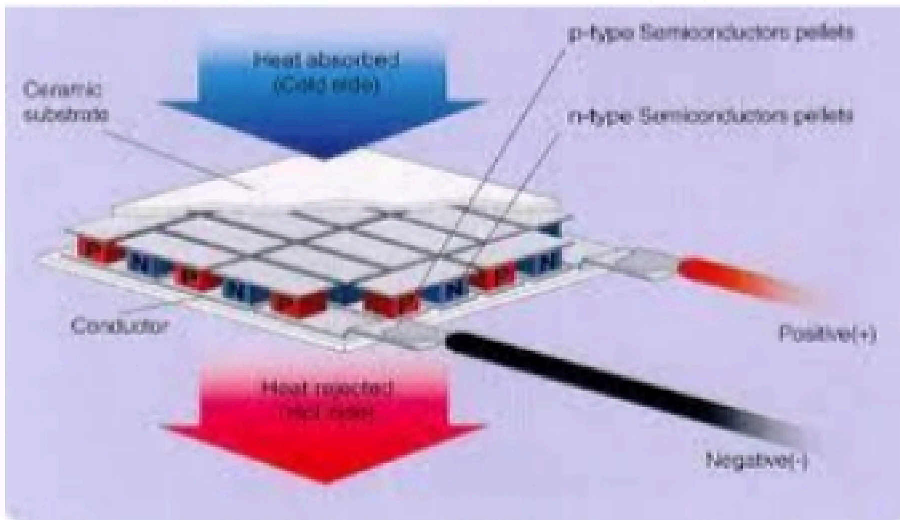

Fig 3.1.5 Entire Assembly of peltier Module.

3.1.6 Solar Energy

Solar energy is a source of abundant free energy from the sun, solar energy has vast prospect to utilize in several areas to mitigate the energy demand of everyday use. Besides the conventional lighting purpose, solar energy can be harnessed to use for refrigeration system, mainly in off-grid areas.

3.1.7 Usage of Solar for Refrigeration

The solar energy is made to use for refrigeration by using solar panel that is connected to the battery through charge controller. The radiation from sun is absorbed by solar panel consisting of photovoltaic cell which converts the sunlight into DC electrical power which drives the refrigerator.

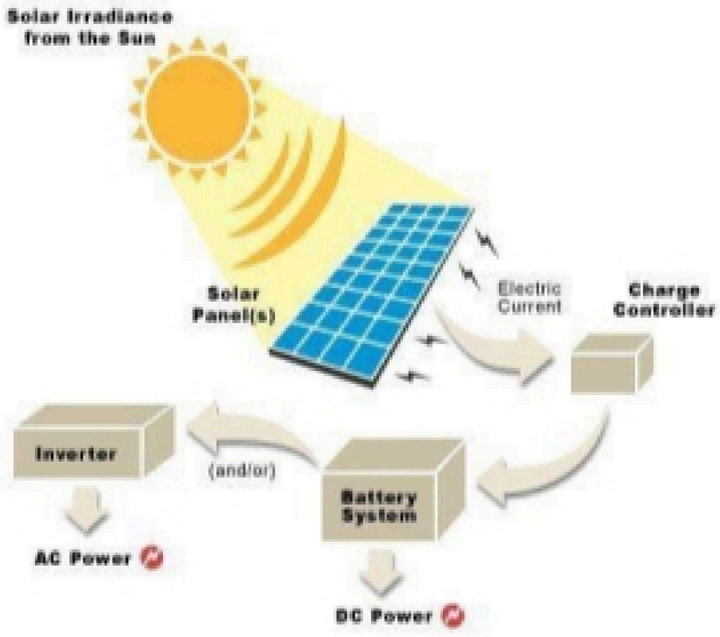

Fig 3.1.7 Usage of solar energy for Refrigeration.

3.2 Equipment used

1. Aluminium Sheets

We have used aluminium sheets around the insulating box for conduction and achieve cooling rapidly. It receives chilling effect from one side of the peltier and transfer to the storage.

2. Insulation Box

We have used Thermocol material for insulating box of inner dimension 40cm*32cm*24cm and outer dimension of 43cm*35cm*27cm. As we know the ice vendors take advantage of thermocol for its economic value and good insulation property as it does not allow inner temperature to cool down.

3. Peltier Module

Peltier specification: maximum current 6A, maximum temperature difference Tmax = 68 degree Celsius. Maximum voltage max 15.2v, Resistance: 1.94 +/- 0.1.

4. Heat Sink

A heat sink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device.

5. Fan

We have used two fans, one is for blowing cold air to the refrigerator and another for to escape the heat from heat sink.

6. Battery

Peltier device is powered by 12v battery. An electric battery is a device consisting of two or more electrochemical cells that convert stored that convert stored chemical energy into electrical energy.

7. Solar Panel

We have used solar panel having specifications power 10w minimum at 16.4v and min 25 degree Celsius required for solar panel to function.

8. Charge Controller

It's a Build-in microcontroller. Big LCD display, all adjustable parameter. Fully 3-stage charge management. Dual USB output, the maximum current of 2.5A, Dual mosfet Reverse current protection, low heat production. Operating temperature -35 to +60 degree Celsius.

We made usage of the kit containing two heat sinks, and two fans whose figure is shown below.

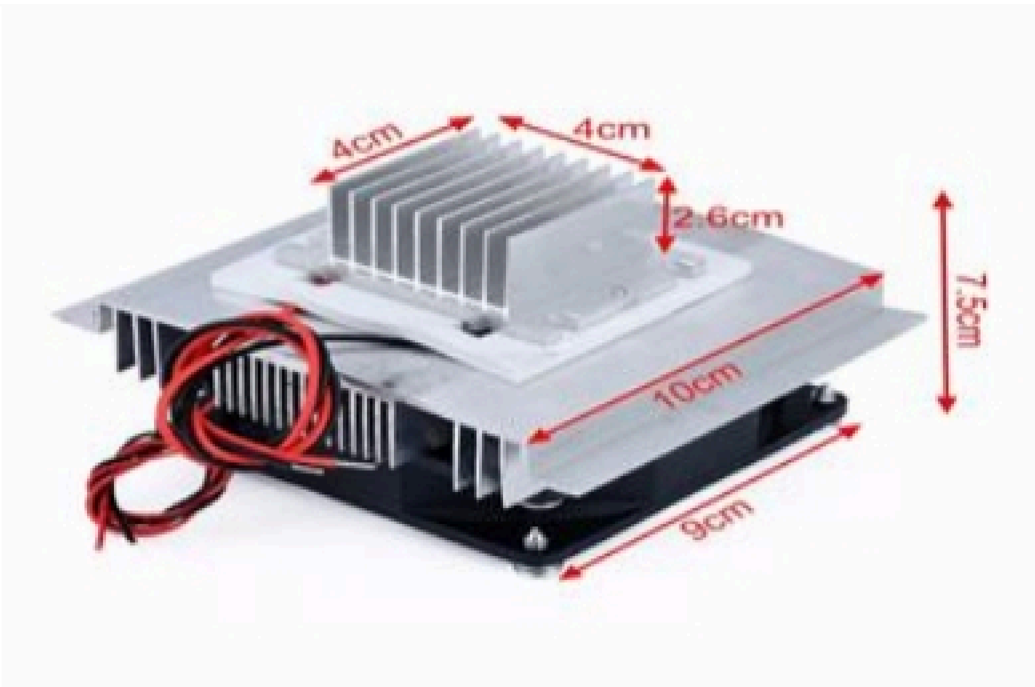

Fig 3.2 Kit containing heat sinks and fan.

3.3 Design and Construction

3.3.1 Dimension of the Refrigerator

1. **Outer Dimensions**

- Length = 43cm
- Breadth = 35cm
- Height = 27cm

2. **Inner Dimensions**

- Length = 40cm
- Breadth = 32cm
- Height = 24cm

3.3.2 Proposed Sketch

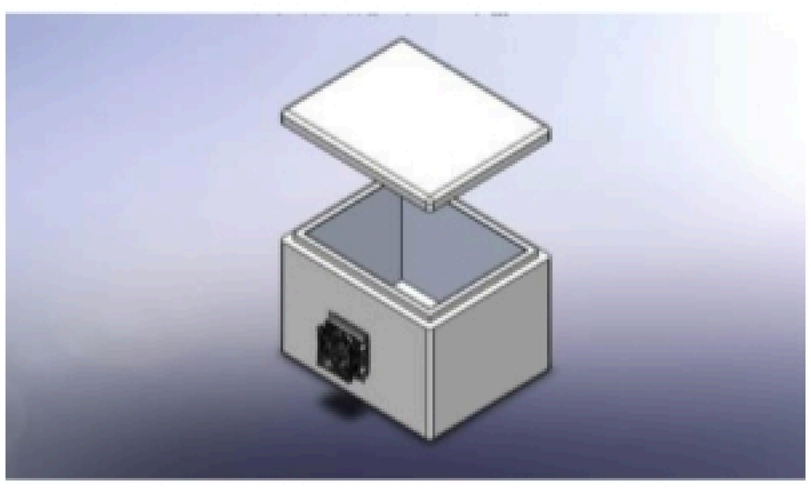

Fig 3.3.2.1 Design of the Refrigerator

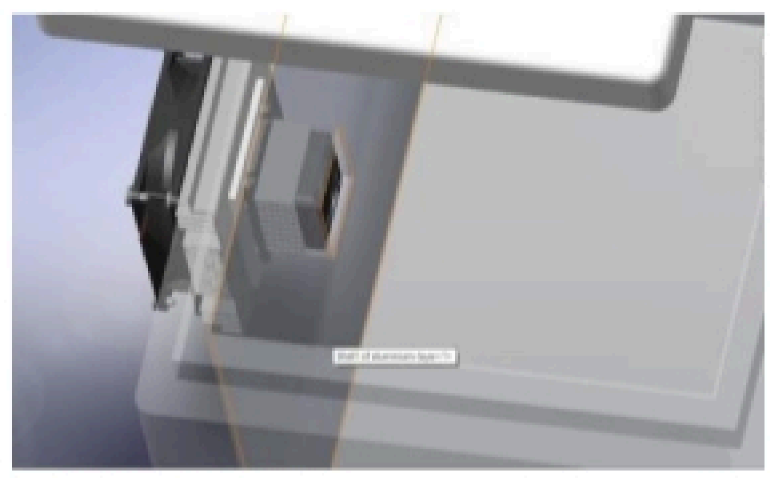

Fig 3.3.2.2 A look at peltier and heat sink Assembly

3.3.3 Circuit

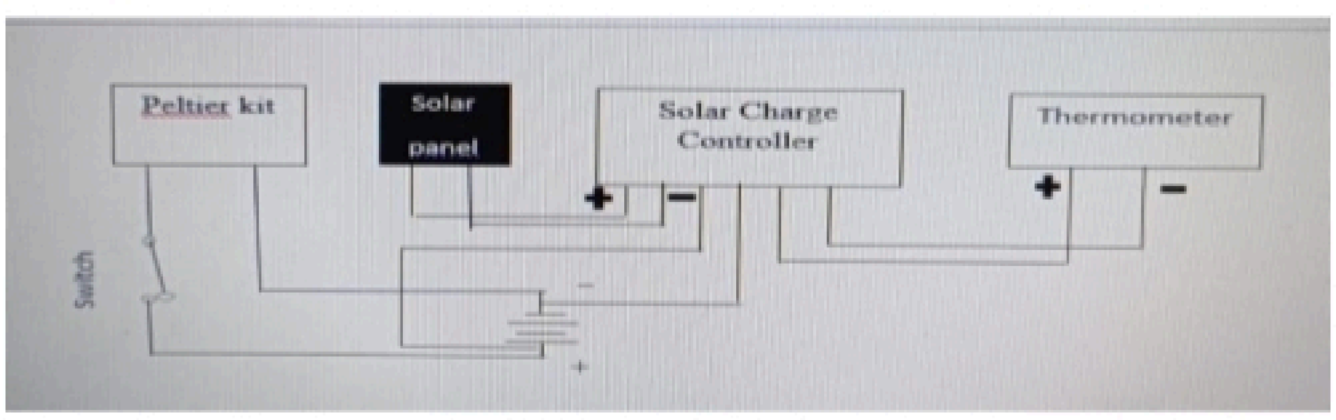

Fig 3.3.3 Circuit

3.3.4 Manufacturing and Fabricating Plan.

1. Manufacturing plan

- Make cavity for fan and peltier module in box
- Fit the fan in the box
- Connected the circuit and make the connection of diode with solar panel and Connect battery to solar panel
- In this step we made three connections with battery

a) Battery to display unit b) battery to peltier module c) battery to fan

- In this step we finally assemble the all parts and thus the model is prepared.

2. Fabricating Plan
   - First we have the thermocol box.
   - Then we make section in it with equal dimension of fin to make fit in it.
   - Fit the peltier module on back side of heat sink (fin).
   - Place the fin, peltier, and fan in the section.
   - Connect all to the battery.
   - Check the proper working of all the components and do the calculation according to it.

3.5 Working and Experimentation.

3.5.1 Working

- First the necessary circuit connection is made.
- When device starts to perform peltier module divides into hot and cold sides.
- Hot side is connected to comparatively larger heat sink because in peltier module it generates larger amount of heat.
- Cold side is connected to smaller heat sink to transfer the cold air.
- The fan connected to smaller heat sink blows the cold air into the storage.
- The fan connected to the larger heat sink escapes the hot air to the atmosphere.
- Thus we obtain cooling inside the box using peltier module.

3.5.2 Experimentation

1. **Analysis**
   - We have done the analysis of temperature of aluminium sheet which is placed inside the box.

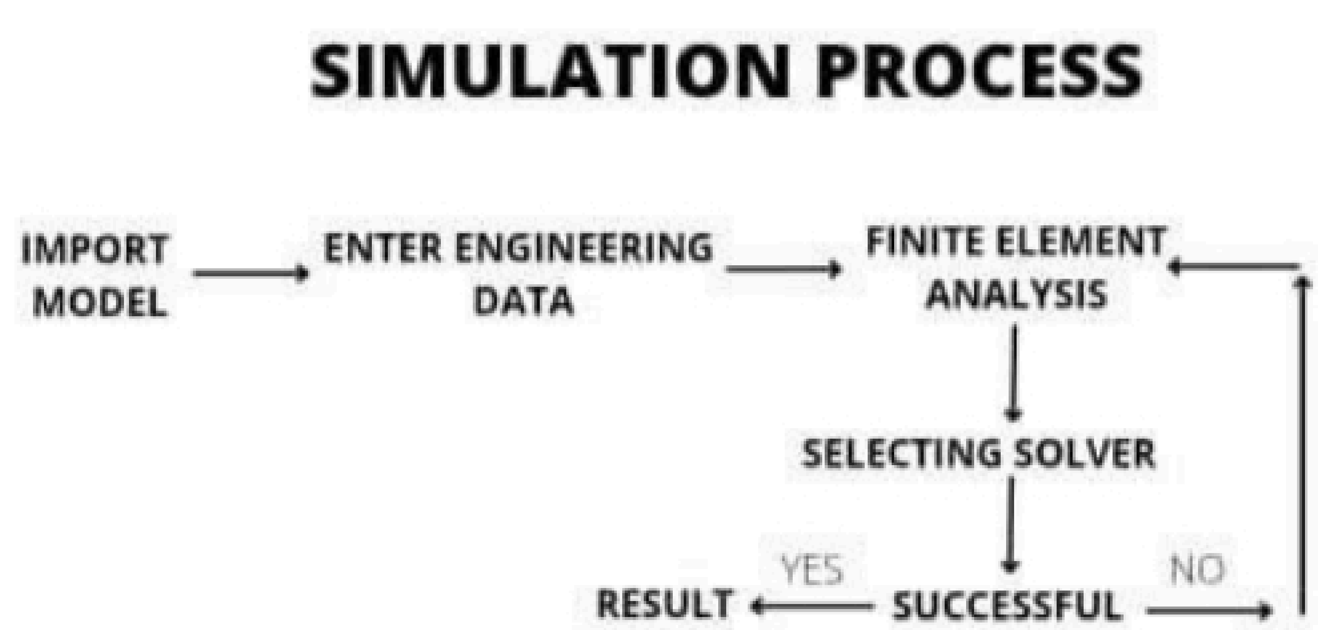

Fig 3.5.2.1 The simulation Process

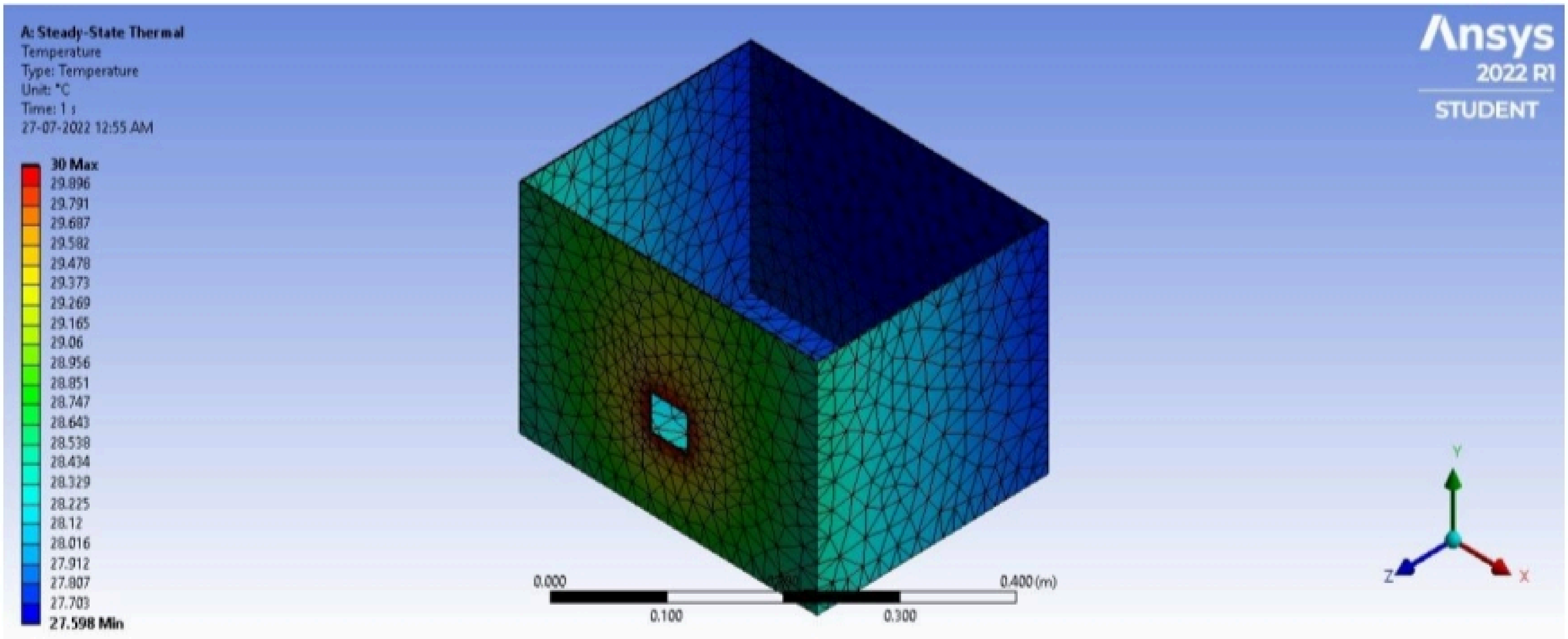

Fig 3.5.2.2 The analysis of the Temperature Gradient

- The analysis shows how the temperature difference occurs inside the box.
- Here we have shown near the heat sink there is a higher temperature as the time progresses the cooling starts from opposite side of the plate.

2. Calculation of Performance of the Refrigerator

- Input Work = Product of Current and Voltage

  = 12v * 10 amp

  = **120 W**

- Initial Temperature of the Water (1L) =____30___degree Celsius
- Final Temperature of the water(1L) =____15___degree Celsius
- Time taken to for temperature to cool down(T) =____65___minutes
- Total Amount of heat removed= $\frac{\text{Mw * Cp * Change in temperature}}{\text{T}}$

  $$= \frac{1000 * 4.187 * (30-15)}{65 * 60}$$

  = **16.10W**

- Co efficient of Performance = $\frac{\text{Total heat removed}}{\text{Input Work}}$

  $$= \frac{16.10}{120}$$

Co efficient of Performance = **0.1345**

Chapter 4

Cost Analysis

Slno.	Equipment	Quantity	Cost in Rs\-
1	Aluminium sheets	1	800
2	Thermacol Box	1	200
3	Solar Panel	1	600
4	Charge Controller	1	580
5	12v Battery	1	550
6	Peltier Module	1	150
7	Heat Sink	2	350
8	Fan	2	320
9	Temperature Display	1	150
	Total cost		3700\-

Table 4.1 Cost Analysis

Chapter 5

Result

- The final result obtained when the testing is done we observed the coefficient of Performance of the refrigeration to be **0.1435.**
- The temperature was reduced to **15 degree Celsius** from temperature of **30 degree Celsius**

Fig 5.1 Final model

Chapter 6

Conclusion

During the construction of the device minor changes were made to the design. Each of this changes we feel was justified as they made for easier construction while maintaining the performance of the device with respect to the project goals. This device passed its final inspection and was deemed to have a professional appearance by the design project coordinator. Using solar based refrigerator as an alternative of using compressor operated refrigerator has many benefits such as saving the environment, cost. The system is self powered & can be used in isolated & a remote part of the country where load-shading is a major problem.

Chapter 7

Future Scope of the Project

In the coming years, technology improvements will ensure that solar becomes even cheaper. It could well be that by 2030, solar will have become the most important source of energy for electricity production in a large part of the world. The solar refrigerator's thermal storage material provides 7 days of reserve cold storage, even in tropical climates, or during extensive periods of cloudy weather when sunlight is not available for energy production. The fan ensure nearly silent operation, while light indicators on the front of the refrigerator inform users of the status of the thermal reserve.

Chapter 8

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