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Peltier Based Eco-Friendly Smart Refrigerator for Rural Areas

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Abstract— This project is a demonstration of an eco-friendly methodology for the implementation of solar powered thermoelectric refrigeration system. Solar energy is the most abundant and renewable source of energy in environment, and hence it is used in our project. In conventional refrigerators, moving parts or rotating parts like compressor, expansion valve, coolants etc. are involved which leads to some vibrations and noise. Even coolants are not eco-friendly and much more costly. But in thermoelectric refrigeration system, these mechanical parts and coolants get eliminated and a thermoelectric module is used instead. Still there are many rural areas where people have to deal with electricity problems, this module will be very helpful to them as it runs on solar energy. Food items and other different required things can be stored in it. Thermoelectric module consists of peltier plates and heat sink module which will be placed on each side of the peltier device. We are using microcontroller for this project. Features we are involving are: Slot detector using IR sensors which will be displaced on the LCD attached outside the cooling system; Temperature and humidity sensor : to control the temperature and set it on required threshold ; Battery charging circuit : this circuit will monitor the battery status and the temperature will be displayed on the LCD screen.

Keywords— LCD, CFCs, HCFCs,

I. INTRODUCTION

Due to the difficulty in disposal of Chlorofluoro carbon (CFCs) and Hydro Chlorofluoro carbons (HCFCs), conventional sources are being used so as to decrease the environmental degradation. As mentioned in the past years, fluoro carbons were used in the refrigerators .Use of these kind of refrigerators are forbidden as these lead to derogation of ozone layer. Moreover, the problem regarding environment is piling up in recent years. Presently the energy saving strategy is one of the top most priority of the world. In particular, the sector of cooling having a heavy influences on the total electrical energy consumption and hence need to be optimised so as to increase the overall performance. Solar energy being abundant in nature, thermo electricity can be used in the generation of power for cooling and heating applications. Therefore, the need of thermo electric refrigeration is on demand particularly for the upcoming developing countries where long life of appliances and low maintenances are needed.

The working of thermo electric module is based on the peltier effect in which a temperature difference is developed between the two junctions of the thermocouple due to which one side of the peltier becomes cold and other hot. In refrigerator space, cool side of the thermocouple model is used whereas hot side is used for the rejection of heat to atmosphere with the help of heat sink [1]. The size of the peltier varies from very small to very large size according to the requirement and application.

THERMOELECTRIC MODULE

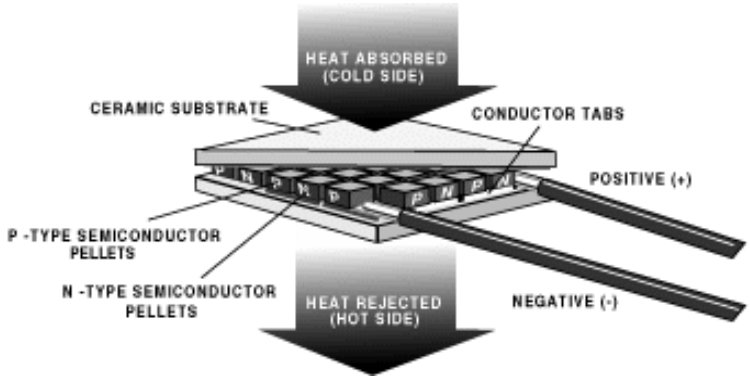

Figure: Working Principle of Thermoelectric Module

A typical peltier plate is of 4x4cm^2 semiconductor. Thermoelectric module is made up of thin ceramic wafers with P and N bismuth telluride semiconductor material connected in series between them. These elements are electrically parallel connected .The doping of P type semiconductor is done with some atoms having fewer electrons than what is

required to complete the atomic bond within the crystal lattice. The thermoelectric couples are thermally in parallel while electrically in series. The thermoelectric module work according to peltier effect. The peltier effect produces a temperature difference by exchanging heat between two electrical junctions. A potential difference is applied across joined conductors to generate current. As the electrons travels from P type material to N type material, the electrons hop to the higher energy state hence absorbing thermal energy (cold side). Then as the electrons travels from N type material to P type material, the electrons drop to the lower energy state hence dissipating thermal energy (hot side). The higher is the rate of dissipation of heat, the cooler it gets inside the cabinet and hence increasing the efficiency of the cooling module proportionally.

II. LITERATURE SURVEY

In thermoelectric refrigeration system all mechanical part are eliminated and it replaced by thermoelectric module.

Ganesh S. Dhumal, P.A. Deshmukh, M. L. Kulkarni has work on thermoelectric refrigeration system running on solar energy and development of mathematical model the study showed about Mathematical and theoretical characteristics of thermoelectric module the experimental capacity of refrigerator is 0.5 litter using two peltier plate and heat sink module beside the platier plate to element the maximum number of heat from hot side of plate as per analysis result decreased the temperature is up to 24^0 C in 7 minutes.[1].

Nandini K.K., Muralidhara worked on Peltier Based Cabinet Cooling System Using Heat Pipe And Liquid Based Heat Sink they used heat sink as well as using heat pipe, The hot side of both the peltier device is
attached to same liquid based heat sink and cold side is attached to heat pipe based heat sink the system had 10 fins on top and bottom side of cover plate was designed and fabricated using aluminium material[2].

Palash Nakhate , Niraj Pawaskar , Purva Vatamwar , Saurabh Kalambe have worked on Ecofriendly Refrigerator Using Peltier Device they given 12v supply through a Switch Mode Power Supply(SMPS) Peltier plate and heat sink fan module,they did not used a solar energy for supply unit of project hence a suitable temperature range for perishable food storage is 3 to 5 °C (37 to 41 °F), with the use of microcontroller designed a feedback unit for unit where the container is cooled to required temperature at that point supply automatically turn off[3].

A study on Solar Refrigeration Using Peltier Effect was carried out by Prof. Pushkarny B.H. , Divyesh Patel, Akshay Parulkar, Hitesh Rai, Nadeem Khan has worked solar energy according to study a solar cell has been used to develop 17v and 1.16 Amp current DC supply i.e power is up to 20w of his solar cell through energy the electrical energy is stored in a 12 v DC supply with 7.2Ah current battery. Power capacity of refrigerator is 60w and the capacity of cooling chamber of refrigerator is 7.8 litter [4].

III. EXPERIMENTAL SETUP

The inner cabinet is made air tight with 4 mm of medium density fiber board of 30 cm × 30 cm × 14cm which is internally covered with aluminium sheet from all sides having a total capacity of 12.5 liters. The cabinet is insulated by 3 cm thick polystyrene sheet from outside for thermal insulation from surrounding and the polystyrene sheet is covered with 4 mm of medium density fibre board for maintaining the rigidity of the cabinet. The door is attached with hinges for better and easy movement of it.

Figure: Construction of refrigerator

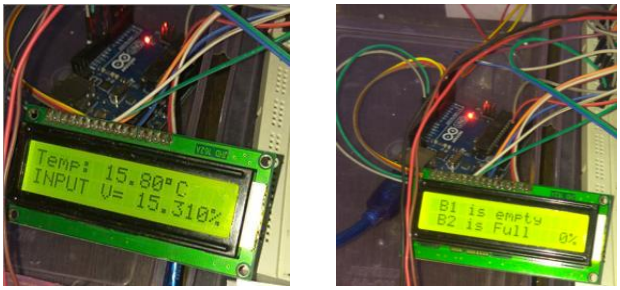

Figure: LCD Display

IV. RESULT

The refrigeration unit can cool itself in 7 hours and the temperature reached in two hours is up to 14° C. The cooling unit is efficient enough to maintain the temperature through feedback network system. Temperature and humidity sensor help in monitoring the temperature inside the cooling unit.

Designed and developed an thermoelectric cooling system with a refrigeration space of 12.5 liters capacity enclosed in the box of medium density fiber sheet and insulated by polystyrene sheet. A 2mm thick aluminium sheet is fixed inside the box for uniform distribution of temperature.

Three thermoelectric modules are have been used to reduce the temperature of the cooling system. Each thermoelectric module is in contact with respective heat sink fans hence helping the hot side of the peltier plate to dissipate more of heat in the surrounding.

- Desired temperature of cold compartment = 14°C
- Ambient temperature = 32°C
- Thermal conductivity of aluminum = 167 W/M
- Dimension of cabinet =30 cm × 30 cm × 14 cm
- Highest ambient temperature a heat sink can handle = T_{am} = 15°C

Therefore,

Temperature difference = (32°C + T_{am}) - 14°
= (32°C + 15°) - 14°
= 33°C

So, 39°C of heat is to be exchanged or dissipated by the heat sink and peltier module.

Using Newton's law of cooling:

$$qc = mCp \times (T_{am} - T_c)$$
$$= 12.5 \times 4180 (32- 14)$$
$$= 940500 \text{ J}$$
$$qc = 940500 / (420 \times 18)$$
$$qc = 124.40 \text{ watt}$$

Thus 125 watts to be precise watts to be distributed among three peltier plate module with 41.66 watts per module. Thus, 125 W solar panel as per standard.

Observation Table:

Table I Night

Sr.no	Time (1 hour delay)	Temperature in ℃
1.	8:30pm	32°
2.	9:30pm	28°
3.	10:30pm	25°
4.	11:30pm	22°
5.	12:30am	19°
6.	1:00am	16°
7.	1:30am	14.28°

Table III Day

Sr.no	Time (1 hour delay)	Temperature in ℃
1.	10:00am	35°
2.	11:00 am	33°
3.	12:00pm	30°
4.	1:00pm	28.34°
5.	2:00pm	27.38°
6.	3:00pm	25°
7.	4:00pm	22°
8.	5:00pm	19°
9.	6:00pm	16°
10.	6:30pm	15°

V. CONCLUSION

This solar powered peltier refrigerator is more reliable than other portable refrigerators. It is cost efficient and eco-friendly which is the most wanted requirement of today's era. By controlling the temperature range of the cooling unit, it can be used in various sectors like for in the rural areas where dairy products need a lot of attention, near the coasts from where the marine edibles need to be transported to the market area, medical area for storing blood and pharmaceuticals.

The efficiency of the refrigerator can be increased by increasing the number of peltier plate module which will eventually help in decreasing the temperature in less time. Number of peltier plate modules used can be calculated using the heat transfer formula.

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