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Solar Power Solid State Refrigeration

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Abstract:
The main objective of the paper is to design and fabricate a cooling system which utilizes non-conventional energy source to run the system. This will be suitable and affordable to the people living in sub-urban areas which are prone with load-shading problems. The major advancement in our system is the absence of mechanical moving parts which reduce the co-efficient of performance of the system. The module is compact and reliable. It is economical and eco-friendly due to absence of harmful refrigerants.

I. INTRODUCTION
From last century till now refrigeration has been one of the most important factors of our daily life. The current tendency of the world is to look at renewable energy resources as a source of energy. This is done for the following two reasons; firstly, the lower quality of life due to air pollution; and, secondly, due to the pressure of the ever increasing world population puts on our natural energy resources. From these two facts comes the realization that the natural energy resources available will not last indefinitely. The basic idea is implementation of photovoltaic driven refrigerating system powered from direct current source or solar panel (when needed) with a battery bank. In 1821, the first important discovery relating to thermoelectricity occurred by German scientist Thomas Seebeck who found that an electric current would flow continuously in a closed circuit made up of two dissimilar metals, provided that the junctions of the metals were maintained at two different temperatures. Without actually comprehending the scientific basis for the discovery, Seebeck, falsely assumed that flowing heat produced the same effect as flowing electric current. Later, in 1834, while investigating the Seebeck Effect, a French watchmaker and part-time physicist, Jean Peltier found that there was an opposite phenomenon where by thermal energy could be absorbed at one dissimilar metal junction and discharged at the other junction when an electric current flows within the closed circuit.

Afterwards, William Thomson described a relationship between Seebeck and Peltier Effect without any practical application. After studying some of the earlier thermoelectric work, Russian scientists in 1930s, inspired the development of practical thermoelectric modules based on modern semiconductor technology by replacing dissimilar metals with doped semiconductor material used in early experiments. The Seebeck, Peltier and Thomson effects, together with several other phenomena, form the basis of functional thermoelectric modules. Thermoelectric Refrigeration aims at providing cooling effect by using thermoelectric effects rather than the more prevalent conventional methods like those using the ‘vapour compression cycle’ or the ‘gas compression cycle.

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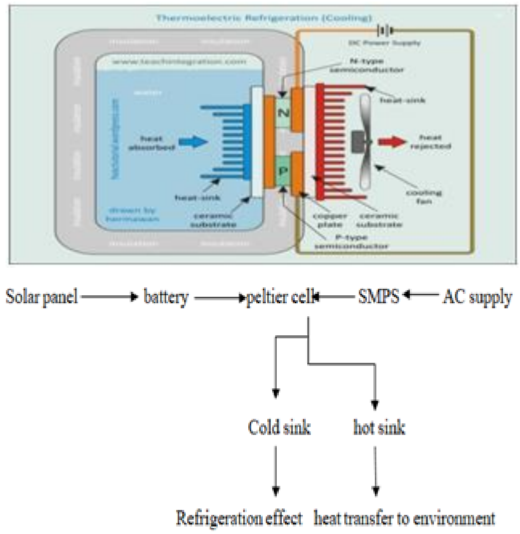

Figure 1: Solar Power Solid State Refrigeration Cycle

II. PROTOTYPE TESTING

Main requirement for solar power solid state refrigeration is solar panel, then comes the battery which stores electric current, switches, copper wires of required length (more in number), Switch mode power supply (SMPS), charge controller, power supply board, relay, capacitors, sensor or blinkers, power connector, on/off switch, a wooden board with respective required dimensions to arrange all the electric circuit on the wooden board. Then comes wooden cuboids which resembles refrigeration body, air circulating cooling fans, peltier cells ,fins ,hot sink , Cold sink, thermal paste, rexine cloth, Screws, temperature indicator.

Figure 2: Prototype Model

Solar Panel Specifications

Maximum power (Pmax)	:	5W
Rated power	:	12V
Voltage at Pmax	:	17.4V
Current at Pmax	:	290mA
Open circuit voltage	:	21.8V
Short circuit current	:	310mA
Weight	:	0.67kg
Dimensions (W*H*D)	:	251*205*18 mm

Battery

Battery is very essential and important component, which is used to store the electricity trapped by the solar panel and helps in further usage of trapped current to refrigeration purpose. 12v/7amp

Temperature Indicator

It Indicates temperature created by the peltier cell inside and sticked to cold sink.

Figure 3: Temperature indicator

Refrigeration Cubical

Arranged with fins and air circulating fans wooden board, covered with rexine cloth, peltier cells, temperature indicator etc

Figure 4: Refrigeration cubical

SMPS

AC to DC converter connected directly to domestic current supply via plug provided, socket connection. When lacking solar power.

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Switch Mode

Switch is used for special purpose, to switch the directional flow of current, i.e solar power or ac supply.

III. DESIGN CALCULATIONS

Specifications

Peltier material used –bismuth telluride
A=0.04x0.04=0.0016m^2
Pmax=92W
Vmax=12Vdc
ΔTmax=70̊c

Battery Specifications

Voltage 12v
Current 7Ah

Theoretical calculations

C.O.P= Q/W
Q = Heat absorbed = α / Tc – 0.512r – K (Th- Tc)
W = Work supplied = α l (Th – Tc) + l^2 R
α = See beck coefficient = v/Th = 140 μV/K
R- Resistance = 0.26 ohms at 23̊c
I = current
Th = Temperature of hot surface = 60
Tc = Temperature of cold = 5
K = Thermal conductivity
= ((Th – ΔTmax)x V x I) / (2(ΔTmax x Th))
K = ((60-70) x 12 x 7) / 2 (70 x 60)
K = -10 x 12 x 7 / 2 x 70 x 60 = -1/10
K = -0.1
Q = 140 (7) (5) – 0.512 (0.26) – 0.1 (60-5)
Q = 4900 – 0.133 – 5.5
Q = 4894.3
W = α l (Th – Tc) + l^2 R
W= 140(7) (60-5) + (7)^2 (0.26)
W= 63,700 + 12.74
W = 63712.74
C.O.P = Q/W=4894.3/63712.74=0.076 KJ

Actual efficiency

C.O.P = Q/P
Q = MCp ΔT / t x 60
Therefore, m= 1kg
Cp = 1.03
ΔT = 70
t = 1hr
Q = 72.1 / 60
Q = 1. 20
P = V x I=12 x7= 84
C.O.P = 1.20 / 84= O.O143KJ
Efficiency = Actual / theoretical= 0.0143/0.076= 20%

IV. WORKING PROCEDURE

Our main objective was to achieve the counter phase mechanism. Solar power solid state refrigeration is equipment which was designed to create the refrigeration effect using solar radiation. In this type of refrigeration moving parts are eliminated. The main difference between normal refrigeration and solid state of refrigeration is absence of compressor. Due to lack of compressor, vibrations will be reduced and it can be easily transportable. Primary working starts from the solar panel. Solar panel absorbs solar radiations emitted from the sun. When these solar radiations strike the solar panel photons are emitted, which cause in flow of electrons, or discharge of electrons. Due to this, electrical flow is created. This to perform trapped electricity is sent to battery, battery stores the current and used further for refrigeration process.

From battery a wire is drawn to connect to the peltier cell. When current is passed through peltier cell, two junctions are created. Peltier cells are the combination of p and n diodes of 120 junctions. When electricity is passed through peltier cell two junctions are created "hot junction and cold junction". We use this effect, to produce refrigeration effect. This cold generating point is attached to the cold sink and heated side is kept in contact with hot sink which is left to outer environment. An air circulating fan is fixed on top of the ceiling in vertical axis. The air produced is passed through or on fins by creating temperature difference inside chamber as compared to ambient temperature. Secondary process is an optional work which is very helpful when solar energy trapped is less than

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optimum requirement. SMPS is used for this process. It is to draw the alternating current from our domestic house hold current and convert it into direct current. When power is not sufficient or when availability is low, sensors are used to switch from solar process to SMPS. The converted dc is used to perform the refrigeration effect. Heat sinks or outer fins are provided with air circulating fan to reduce the temperature released outside.

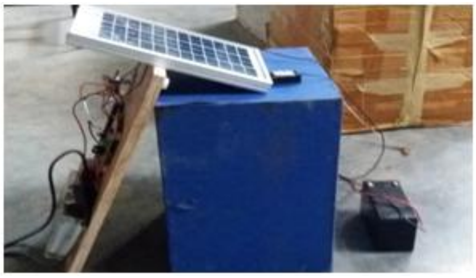

Figure 5: Working model

Advantages

- Solid state heat pump has no moving parts,
- No Freon's or other liquid or gaseous refrigerants required,
- Noiseless operation,
- Compact size and light weight makes TEMs well suited for miniature coolers,
- Precise temperature control,
- Relatively low cost and high effectiveness,
- Operation in any orientation,
- Easy to clean aluminum interior,
- Eco-friendly C-pentane, CFC free insulation

Applications

- Medical field- Pharmaceutical industry, medicine and medical equipment storage, etc
- Military- storing of consumable goods in war affected zones, rural area, etc.
- Dairy (milk) industry
- Mechanical industry
- Scientific and Laboratory Equipment-cooling chambers; freezers; cooling incubators; temperature stabilized chambers; cold laboratory plates and tables; thermo-calibrators; stage coolers; thermostats; coolers and temperature stabilizers for multipurpose sensors
- Restaurant and hotel
- Vegetable, fish, fruit, beverage, etc. storage

Electronic— miniature cooling units for incoming stages of highly sensitive receivers and amplifiers; coolers for high power generators, laser emitters and systems, CCD cameras, vacuum and solid-state photo detectors and CPU coolers.

V. CONCLUSION

This paper concludes that solar energy systems must be implemented to overcome increasing electricity crisis. In this work, a portable solar operated system unit was fabricated and tested for the cooling and heating purpose. The system was designed based on the principle of a thermoelectric module to create a hot side and cold side. The cold side of the thermoelectric module was utilized for cooling purposes whereas the rejected heat from the hot side of the module was eliminated using heat sinks and fans. And hot side of the thermo electrical module was utilized for heating purpose. In order to utilize renewable energy, solar energy was integrated to power the thermoelectric module in order to drive the system. Furthermore, the solar thermoelectric cooling and heating system avoids any unnecessary electrical hazards and proves to be environment friendly.

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