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Solar Vaccine Refrigerator by using Phase Change Material

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Abstract: ***Governments all over the world focus on ensuring health care to every citizen. Preserving life saving medicines and making it available even at remote places is a commitment under health care. Preserving the vaccines and keeping them refrigerated all the time is a challenge as the power supply is unavailable or erratic in remote place even today. Solar energy makes a greater impact under these circumstances and can be harnessed to run the vaccine refrigerators. There are number of demonstrations supported by World Health organization (WHO) in the recent past in many countries. The method and design of a solar vaccine refrigeration with phase change material (PCM) which gives a thermal storage (TS). The utilization of PCM as TS will improve the COP (coefficient of performance) of new refrigeration cycle by presenting another sub cooling routine. This improvement sub cooling should be possible by D.C COMPRESSOR instead of A.C Compressor even a double evaporator system for refrigerator/cooler mix. Due to delaying of the compressor off time by utilizing latent heat of the we can have better vaccine storage quality because of lower hysteresis cycle of on/off for a given time of activity. To make a system level demonstrating of the refrigerator and additionally reenacted the energy utilization the new refrigeration cycle with sub cooling using PCM***

Key words: PCM, solar vaccine refrigerator, Solar panel

I. INTRODUCTION

Sun light based energy is essentially the energy created directly by the sun and gathered somewhere else regularly the earth. The sun which creates its energy through a thermo nuclear process that change over around 650,000,000 tons of hydrogen to helium consistently. The process creates heat and electromagnetic radiation the heat remains in the sun and is instrumental in maintaining the thermo nuclear reaction. The electromagnetic radiation streams out into space every which way A small fraction of the total radiation delivered achieves the Earth. The radiation that reaches the earth is the indirect source of almost every kind of energy utilized today. The special cases on geothermal energy and nuclear fission and fusion. In deed even petroleum derivatives owe their causes to the sun: they were once living plants and animals whose life was dependent upon the sun

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Because of the nature of solar energy to parts are required to have a functional solar energy generator. Those to segments or collector and storage unit.

The collector essentially collects the radiation that flaws on it and changes over a small amount of it different types of energy. The storage unit is required as a result of the non-consistent nature of solar energy at specific occasions a very small amount of radiation will be received during evening or night for dump the amount of energy created by the collector will be very small the storage unit can hold the over abundance energy created during the times of maximum productivity and discharge it when the productivity drops.

SIMPLE VAPOR COMPRESSION REFRIGERATION SYSTEM

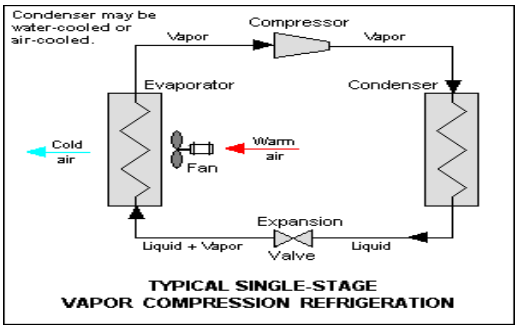

Fig.1: **Vapor compression refrigeration system**

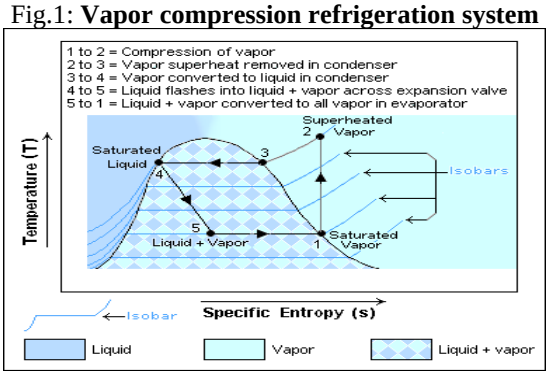

Fig .2: T-S diagram

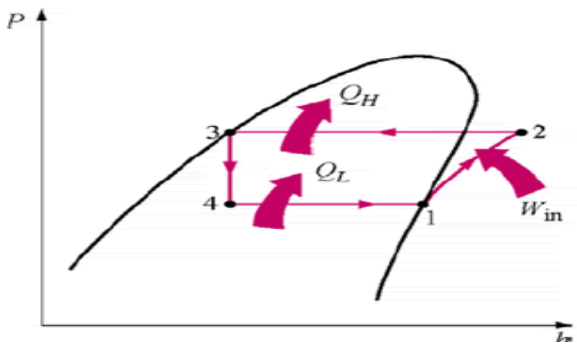

Fig.3: p-h diagram

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II. DESIGN OF SOLAR VACCINE REFRIGERATOR

Fig.4: Solar panel

This part of the system is here and there alluded to as a sun oriented module or photo voltaic generator. Solar panel clusters can be made by interfacing a lot of panels in arrangement or potentially parallel so as to give the important energy to a given load. The electrical flow provided by a solar panel fluctuates relatively to the sun oriented radiation. This will fluctuate as indicated by climatologically conditions, the hour of the day, and the time of the year.

There are several factors that are been carefully considered while selecting the panels First of all we had estimated the load at which the compressor runs in the daily situation at ambient temperature 350C- 450Cfrom that a calculation is done and it is finally we concluded that for a 50 liter refrigerator the minimum power consumption is 800 watts, where as the maximum power consumption is 1000 watts. For a mean solar day the availability of solar energy is for duration of 6 hours.

From the above assumption calculation of panel sizing is done

Total power required = 1000 watts

Total duration = 6 hrs

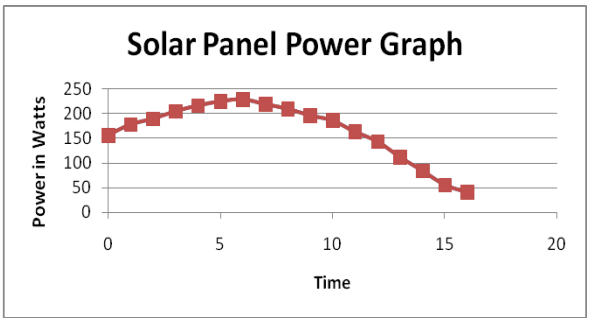
The amount of power to be produced in an hour $= \frac{1000}{06}$

= 167 watts

Based on the above calculation, considering the factor of safety we have considered two 100 watt panels (output=200 watts).The modules that which we used is shown in the below photograph.

Fig.5: Solar panels

III. LOAD CALCULATION



Graph.1: Power graph of Solar Energy:

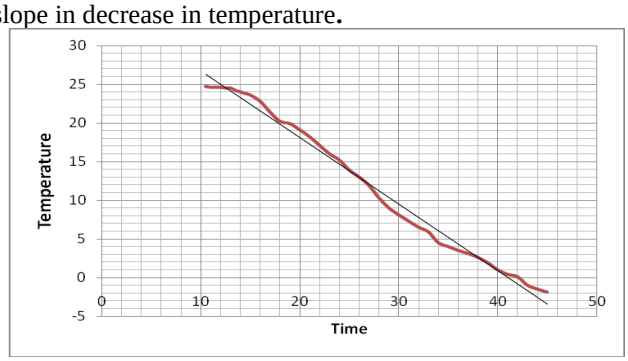
The obtained graph is drawn from time 08:00 am to 06:00 pm for Energy rating of the 2*100 watts solar panels connected in parallel.

It's been shown that 6 hours from commencement time up to noon the power acquired from the panels is raises up to value 230.53W and again it descends to lesser values as the Intensity of the Sun demands. At these times the battery is charged via Charge Controller which is sufficient to run the D.C Compressor.

Cool Down Time for Load:

The time required to cool the 6 liters of Water with 30 kg's of P.C.M is nearly 45 hours from ambient temperature of 27^0c to -1^0c.

Graph.2: The graph is drawn showing the steep slope in decrease in temperature**.**



By Using D.C Compressor:

Time required to cool the load = 45 hours

Amount of Energy consumed by Compressor per hour =100W

Hence,

Energy required to cool the load with P.C.M = 45*100

= 4500W ≈ 5kWatts.

Coefficient of Performance = $\frac{heat\ rejected}{work\ done}$

Heat rejected $=m.c_p.\Delta t$

Where,

M= mass of load with P.C.M =36kg

C_p=specific heat at constant volume ≈1

Δt= Change in temperature $=28^0$c

C.O.P = $\frac{36*2.108*28}{4500}$ =0.4216

Coefficient .Of. Performance =0.4216

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By using A.C Compressor :

Time required to cool the load =45 hours

Amount of Energy consumed by Compressor per hour =0.9 K Watts

Hence, Energy required to cool the load with P.C.M = 45*0.9KW

= 40,500W ≈ 40.5kWatts.

Coefficient of Performance = $\frac{heat\ rejected}{work\ done}$

Heat rejected $=m.c_p.\Delta T$

Where,

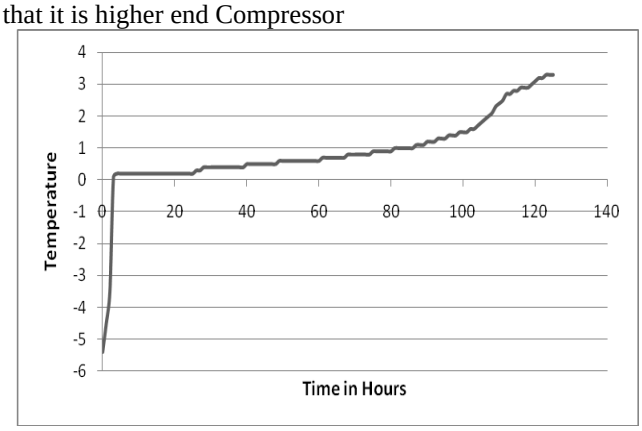
M= mass of load with P.C.M =36kg

C_p=specific heat at constant volume ≈2.108

ΔT= Change in Temperature $=28^0c$

$$C.O.P = \frac{36*2.108*28}{40500} = 0.0524$$

C.O.P of the system by using D.C Compressor is higher compared with C.O.P by using A.C Compressor. This shows the reliability of DANFOSS BD80f D.C Compressor over an A.C Compressor not only under the usage of Current supply by using Solar Panel but also by the results have been shown that it is higher end Compressor



Graph.3: P.C.M Working Graph

When the Power supply is cut off; where there is no chance of Compressor work the graph is drawn by taking **Time in Hours** on *X-axis* & **Temperature in ^{0}C** on Y-*axis*.

- The graph clearly shows that the amount of heat to be rejected during the Refrigeration process is sucked by the P.C.M materials.
- There is a long time taken nearly 82hours for change of Phase from Solid P.C.M to Liquid phase which is the latent heat of it and also the heat rejected by the load.
- Aluminum Container which is the storage ox for carrying load acted as the perfect heat rejecting material for the whole operation to carry out.

IV. TECHNICAL DATA

Table 4.1: technical data

S.No	Parts	Specification
1	Chest dimensions	22x22x31.5inches (lx b x h)
2	Net volume	100 liters
3	Solar panels	2 x 100 watts with 12v output connected in series
4	DC Compressor	BD80F
5	Evaporator	Coil length = 40 feet diameter = 5/16 inch
6	Capillary tube	length = 9 feet Diameter = 0.36mm
7	Condenser	Length = 30 feet Diameter =1/4 inch
8	Battery	Lead acid battery with 12v-150 AH power
9	Charge controller	12v ,10 amps
10	Insulation	100mm thickness PUF
11	Refrigerant	R134a (ECO Friendly)

V. CONCLUSIONS

This project mainly deals with the design of solar vaccine refrigerator with improved coefficient of performance. This is achieved by introducing phase change material with thermal storage device in it.

In which sub cooling of refrigerator is done by D.C compressor rather than A.C compressor by which there is no power fluctuations and due to prolonging of the compressor off time by using the latent heat of energy, we got better vaccine storage quality for a given period of operation.

As it doesn't use any external power supply, this is best suited for remote villages where Power demand is fluctuating or erratic for storing Life Saving Drugs. This can be able to work for more than 4 days of cut off of power supply and makes it beneficial in remote places.

This project given an opportunity to design and develop the total system and that is very relevant to our basic needs of refrigeration. This has generated confidence in us to develop many different Solar Energy based Systems.

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