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SOLAR ASSISTED REFRIGERATION SYSTEM

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ABSTRACT :
The solar refrigerator is the refrigeration system that runs on the solar energy. The solar refrigerator comprises of all the traditional components like the compressor, condenser, expansion valve and the evaporator or the freezer. The power is supplied not by the domestic electrical supply system, but from the solar panel. The solar system of the solar refrigerator comprises of the solar panel that collects the solar energy. The solar panels are fitted with photovoltaic cells that convert the solar energy into electrical energy and store it in the battery. During the normal running of the solar refrigerator the power is supplied directly by the solar panel, but when the output power of solar panels is less, the additional power is supplied by the battery. The battery is recharged when excess amount of power is produced by the solar panels. The output supply of the batteries and the solar panel is DC with voltage of about 12. A typical solar system produces 300W or 600W of power depending upon the size of the desired refrigerator. The voltage regulator is connected to the battery to convert the low voltage DC supply to high voltage AC supply to run the compressor. It is advantageous to use the AC supply compressor since it can run on domestic electrical supply also. Some of the solar refrigerators use compressors that can run directly on DC supply. Another application where the solar energy can be very useful is the vapor absorption refrigeration system. In these systems heat from the steam is used to heat water mixed with lithium bromide or ammonia that act as the refrigerant. In these machines, the heat produced by the steam can be replaced by the heat produced by solar energy.

***KEY WORDS** : Refrigerator, Solar Panel, Battery, Charge Controller.*

1. INTRODUCTION

There are several important reasons for considering solar energy as an energy resource to meet the needs of developing countries. First, most the countries called developing are in or adjacent to the tropics and have good solar radiation available. Secondly, energy is a critical need of these countries but they do not have widely distributed, readily available supplies of conventional energy resources. Thirdly, most of the developing countries are characterised by arid climates, dispersed and inaccessible populations and a lack of investment capital and are thus faced with practically insuperable obstacles to the provision of energy by conventional means, for example, by electrification. In contrast to this solar energy is readily available and is already distributed to the potential users. Fourthly, because of the diffuse nature of solar energy the developments all over the world have been in smaller units which fits well into the pattern of rural economics. Solar refrigeration has the potential to improve the quality of life for people who live in areas where electricity supply is inadequate and important role in industrial and commercial sector for cooling and heating applications. The use of refrigeration is to keep food fresh, has become a part of our daily life in this society. The solar refrigerator is the refrigeration system that runs on the solar energy. The solar refrigerator comprises of all the traditional components like the compressor, condenser, expansion valve and the evaporator or the freezer. The power is supplied not by the domestic electrical supply system, but from the solar panel. The solar system of the solar refrigerator comprises of the solar panel that collects the solar energy. The solar panels are fitted with photovoltaic cells that convert the solar energy into electrical energy and store it in the battery. During the normal running of the solar refrigerator the power is supplied directly by the solar panel, but when the output power of solar panels is less, the additional power is supplied by the battery.

The battery is recharged when excess amount of power is produced by the solar panels. The output supply of the batteries and the solar panel is DC with voltage of about 12. A typical solar system produces 300W or 600W of power depending upon the size of the desired refrigerator. The voltage regulator is connected to the battery to convert the low voltage DC supply to high voltage AC supply to run the compressor. It is advantageous to use the AC supply compressor since it can run on domestic electrical supply also. Some of the solar refrigerators use compressors that can run directly on DC supply.

Figure. 1. Solar Assisted Refrigeration System

2. DESIGN WORK

According to the action plan, the imaginary model was drawn and the location of various parts was set. We have studied various mechanisms to convert the solar energy into electrical energy. A portable stand is made and all the assembly is mounted on the stand.
According to the action plan, we have made the set up of the project.Geometrical parameters are decided by using graphical method.

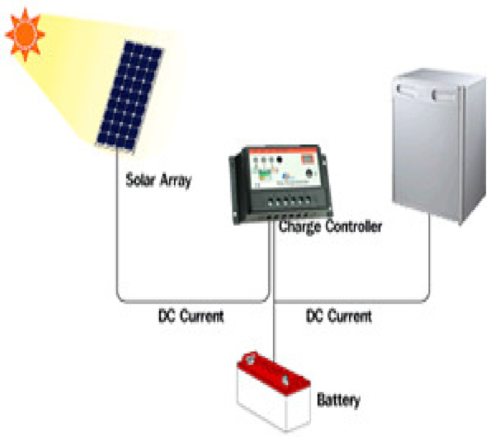

Figure. 2. Concept Model

Figure.3. Set-up of Solar Assisted Refrigeration System

2.1 Battery

Solar-powered refrigeration equipment, or so called off-grid Photo Voltaic (PV) systems, run on direct-current electricity provided by solar energy. Batteries are used to store energy. In off-grid Photo Voltaic (PV) systems batteries are essential to providing power during periods of low or no sunlight.

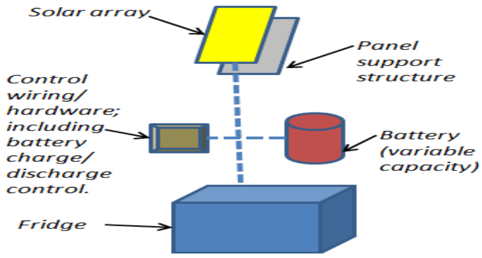

Figure. 4. Battery

(A) Battery Types:
Power packs for battery powered PV refrigeration systems are equipped either with dry charged (=flooded) or Sealed Gel batteries. UNICEF SD recommends the Sealed Gel batteries, which are maintenance free and do not need topping up with distilled water. Flooded batteries are filled with electrolyte supplied in separate hermetic containers when the batteries are delivered. It is important to ensure that the electrolyte level mark on the transparent containers is achieved. Please take note that once the initial level of electrolyte/acid is reached, any consequent topping up is with distilled water only and never again with electrolyte/acid for the rest of the battery's life.
(B) Battery Electrolyte:
With limited exceptions, it is not advisable to procure electrolyte (mixed acid and water at the correct ratio) locally since this requires chemical analysis of the

electrolyte for breakdown in terms of sulphuric technical grade given in level of iron, lead, arsenic, chloride, mercury, and cadmium content in ppm (parts per million). This is to ensure the purity level of the electrolyte. Poor grade of electrolyte severely shortens the useful life of batteries.

(C) Battery maintenance:

For flooded batteries, once the initial top-up of the electrolyte has been done during installation, no further electrolyte should ever be added for the rest of the life of the battery. Distilled (de-ionized) water should be topped up whenever the level gets low. Terminals should be cleaned, tightened from time to time and greased to prevent oxidation.

2.2 Charge Controller

The charge regulators procured for solar powered PV refrigeration systems are designed with an indicator for high/low voltage status. This is important for indicating the state of charge of the battery power pack especially when freezing ice packs. For gel batteries, the charge regulators are specifically configured and calibrated. Care should be taken whenever batteries are changed to ensure the type/model replaced is the same. When replacement is done without recalibration for the type of batteries, the system will not operate optimally.

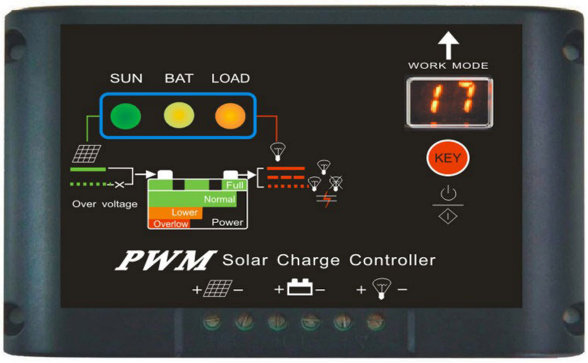

Figure. 5. Charge Controller

2.2.1 Charge Controller Types

Charge controls come in all shapes, sizes, features, and price ranges. They range from the small 4.5 amp (Sunguard) control, up to the 60 to 80 amp MPPT programmable controllers with computer interface. Often, if currents over 60 amps are required, two or more 40 to 80 amp units are wired in parallel. The most common controls used for all battery based systems are in the 4 to 60 amp range, but some of the new MPPT controls such as the Outback Power Flex Max go up to 80 amps.

(A) Simple 1 or 2 stage controls: which rely on relays or shunt transistors to control the voltage in one or two steps. These essentially just short or disconnect the solar panel when a certain voltage is reached. For all practical purposes these are dinosaurs, but you still see a few on old systems - and some of the super cheap ones for sale on the internet. Their only real claim to fame is their reliability - they have so few components, there is not much to break.

(B) 3-Stage and/or PWM: such Morningstar, Xantrex, Blue Sky, Steca, and many others. These are pretty much the industry standard now, but you will occasionally still see some of the older shunt/relay types around, such as in the very cheap systems offered by discounters and mass marketers.

(C) Maximum power point tracking (MPPT): such as those made by Midnite Solar, Xantrex, Outback Power, Morningstar and others. These are the ultimate in controllers, with prices to match - but with efficiencies in the 94% to 98% range, they can save considerable money on larger systems since they provide 10 to 30% more power to the battery. Most controllers come with some kind of indicator, either a simple LED, a series of LED's, or digital meters. Many newer ones, such as the Outback Power, Midnite Classic, Morningstar MPPT, and others now have built in computer interfaces for monitoring and control. The simplest usually have only a couple of small LED lamps, which show that you have power and that you are getting some kind of charge. Most of those with meters will show both voltage and the current coming from the panels and the battery voltage. Some also show how much current is being pulled from the LOAD terminals.

2.3 Solar Panel

A solar cell, or photovoltaic cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels.

Solar cells are described as being photovoltaic irrespective of whether the source is sunlight or an artificial light. They are used as a photo detector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

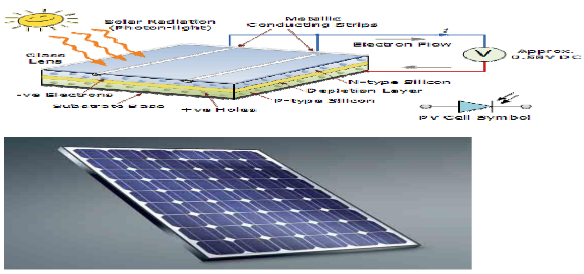

Figure. 6. Solar Panel

In contrast, a solar thermal collector supplies heat by absorbing sunlight, for the purpose of either direct heating or indirect electrical power generation from heat. A "photo electrolytic cell" (photoelectron chemical cell), on the other hand, refers either to a type of photovoltaic cell (like that developed by Edmond Becquerel and modern dye-sensitized solar cells), or to a device that splits water directly into hydrogen and oxygen using only solar illumination.

The solar cell works in several steps:

1.Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.

2.Electrons are excited from their current molecular/atomic orbital. Once excited an electron can either dissipate the energy as heat and return to its orbital or travel through the cell until it reaches an electrode. Current flows through the material to cancel the potential and this electricity is captured. The chemical bonds of the material are vital for this process to work, and usually silicon is used in two layers, one layer being bonded with boron, the other phosphorus. These layers have different chemical electric charges and subsequently both drive and direct the current of electrons.[2]

3.An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

4.An inverter can convert the power to alternating current (AC).

3. CALCULATION

Solar PV System Design

A solar PV system design can be done in four steps:

A. Load estimation

B. Estimation of number of PV panels.

C. Base condition: 1 Refrigerator (50 Watts) for 6hrs a day.

1.The total energy requirement of the system (total load) i.e Total connected load to PV panel system

= No. of units × rating of equipment = 1*50 = 50 watts

2. Total watt-hours rating of the system

= Total connected load (watts) × Operating hours = 50 × 6 = 300 watt-hours

3. Actual power output of a PV panel = Peak power rating × operating factor

= 20 × 0.75 = 15 watt

4. The power used at the end use is less (due to lower combined efficiency of the system

= Actual power output of a panel × combined efficiency
= 15 × 0.81 = 12.15 watts (VA)
= 12.15 watts

5. Energy produced by one 20 Wp panel in a day

= Actual power output × 6 hours/day (peak equivalent)
= 12.15 × 6 = 72.9 watts-hour

6. Number of solar panels required to satisfy given estimated daily load :

= (Total watt-hour rating (daily load)/(Daily energy produced by a panel)
=300/72.9 = 4.1 = 5 (round figure)

7.Inverter size is to be calculated as :

Total connected load to PV panel system = 50 watts

Inverter are available with rating of 100, 200, 500 VA, etc.

Therefore, the choice of the inverter should be 100VA.

4. ADVANTAGES

1. The solar refrigerator runs on solar energy there is lots of saving of electrical power that would have been produced by the conventional power plants causing lots of pollution.
2. The solar refrigerators can be very useful in far off remote places where there is no continuous supply of electricity.
3. The solar energy is available freely, abundantly and is a clean source of energy.
4. One of additional advantage is that the excess power produced by the solar refrigerator can be used for the other domestic purposes.
5. The fishermen use solar refrigerator for keeping the fishes fresh.
6. It can be used in food storage plants.
7.Refrigeration system having low maintenance cost.

5. DISADVANTAGES

1. It can be used only in places where strong sun rays are available throughout the year and most parts of the day.
2. Solar refrigerator is the size of the solar collector occupying large areas of the home.
3. COP is comparatively low as compared to electricity supplied refrigeration system.

6. RESULTS AND DISCUSSION

The refrigeration system that uses solar as the main source of energy has more advantages than its disadvantages. It can help the developing countries to achieve their development goals since there will be less power consumed from the national grid. The implementation of different fluid pairs for the refrigeration systems results into different values of Coefficient of performance. After carrying out through research, it has been proven that combining battery and charge controller can be one of the best ways to achieve refrigeration through the use of the solar energy. In this project. we have taken an insight overview on the design of a solar powered refrigeration system. From the above discussions, it is evident that solar powered refrigeration systems can be used to produce a wide range of cold temperatures. There are quite a number of technologies that are available that not only meet the cooling needs but helps in energy conservation and admirable environment management practices.

7.CONCLUSIONS

After carrying out thorough research and analysis in the field of solar powered refrigeration systems, we can conclude that implementing a solar refrigeration system is one of the best ways of achieving efficiency and ensuring that environment conservation is upheld. There is need to carry out more research in this field since the available literature cannot satisfactorily help in implementing more sophisticated solar refrigeration units that can be able to handle huge tasks. Using solar energy to provide the driving force for the refrigeration system is a big achievement in the field of designing solar appliances and equipments. It is not only cheap but also helps in reducing energy consumption from the natural grid and also reducing environmental pollution.

Solar Assisted Refrigeration System are being used for industrial and household refrigerating purposes. These refrigerating systems are more applicable in remote areas where conventional refrigerating is difficult and solar energy is readily available. These systems are also more suitable than conventional vapor compression refrigeration systems as working fluid used does not create pollution. This process does not create any type of pollution and it is very efficient.

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