Review on Standalone Solar Refrigerator Powered by DC Motor

Merzad M. Elavia[1], Tejendra B. Patel[2]

[1] *ME PERSUING, THERMAL ENGINEERING, MGITER NAVSARI, GUJARAT, INDIA*
[2]*ASSISTANT PROFESSOR, THERMAL ENGINEERING, MGITER NAVSARI, GUJARAT, INDIA*

ABSTRACT

In India, there are several places where the electrical power is not continuously available therefore food storage and vaccine preservation is not possible and people are losing their lives. A solar-powered refrigerator is a refrigerator which runs on energy directly provided by sun, and may include photovoltaic or solar thermal energy. Solar-powered refrigerators are able to keep perishable goods such as meat and dairy cool in hot climates, and are used to keep much needed vaccines at their appropriate temperature to avoid spoilage. Solar-powered refrigerators may be most commonly used in the developing world to help mitigate poverty and climate change. Solar energy based refrigerators may overcome the issue. The electricity generated through photovoltaic panels can be used to drive the refrigeration systems. Here the performance analysis of solar assisted VCR system driven by DC compressor will be done. The model which is planned to be prepared will be a refrigeration system whose conventional compressor will be replaced by DC compressor so as to remove the cost of alternator. That DC compressor will be powered by DC current which is produced by solar panel. The remaining cycle will operate as conventional refrigeration system.

Keyword: - *Solar refrigerator, DC motor*

1. INTRODUCTION

There are environmental concerns regarding conventional refrigeration technologies including contribution to ozone layer depletion and global warming. Refrigerators which contain ozone depleting and global warming substances like chlorofluorocarbons (CFCs), in their insulation foam or their refrigerant cycle, are the most harmful. After CFCs were banned in the 1980s, they were replaced with substances such as hydro chlorofluorocarbons (HCFCs), which are ozone-depleting substances and hydro fluorocarbons (HFCs). Both are environmentally destructive as potential global warming chemicals. If a conventional refrigerator is inefficient or used inefficiently, it will also contribute more to global warming than a highly efficient refrigerator. The use of solar energy to power refrigeration strives to minimize the negative impacts refrigerators have on the environment. Traditionally solar-powered refrigerators and vaccine coolers use a combination of solar panels and lead batteries to store energy for cloudy days and at night in the absence of sunlight to keep their contents cool.

The model which is planned to be prepared will be a refrigeration system whose conventional compressor will be replaced by DC compressor so as to remove the cost of alternator. That DC compressor will be powered by DC current which is produced by solar panel. The remaining cycle will operate as conventional refrigeration system.

Fig -1: Domestic solar VCR system [1]

Photovoltaic (PV) involve the direct conversion of solar radiation to direct current (dc) electricity using semiconducting materials. In concept, the operation of a PV-powered solar refrigeration cycle is simple. Solar photovoltaic panels produce dc electrical power that can be used to operate a dc motor, which is coupled to the compressor of a vapor compression refrigeration system. The major considerations in designing a PV-refrigeration cycle involve appropriately matching the electrical characteristics of the motor driving the compressor with the available current and voltage being produced by the PV array.

2. LITRETURE REVIEW

Asmaa Ahmed M. El-Bahloul et al. [2] has done experimental investigation on performance of solar driven with direct current motor vapor compression refrigerator through indoor and outdoor tests with/without thermal storage and with/without loading. The experimental setup main components are multi-crystalline Photovoltaic PV module, battery as a buffer for constant 12V DC and 50 liter portable refrigerator with/without PCM thermal energy storage. In addition, a theoretical model is established to evaluate the refrigerator performance when operated under different environmental conditions of the design point.
The following results were obtained:
- Use of PCM gives low COP.
- But there will be nothing to compensate until the solar energy is available if we do not use PCM.
- COP is found to be more for indoor condition.

S. R. Kalbande et al. [3] used a DC refrigerator powered by a field of solar panels, a battery bank and a solar charge controller. DC refrigerator of 25L capacity powered by two solar panels of 80W, battery of 12V and charge controller was used. Photovoltaic efficiency at no load and full load condition was calculated.

Energy consumption was found out about 429-660 W per day.

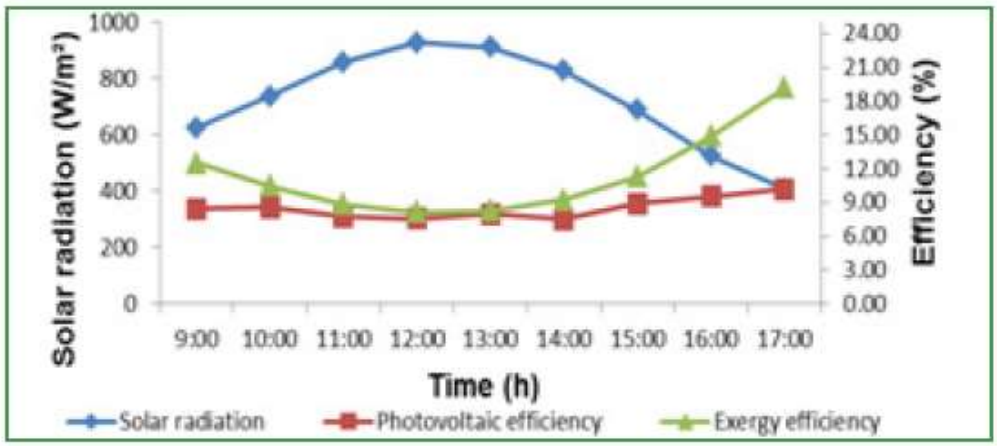

Fig -2 Change in photovoltaic efficiency and solar radiation with respect to time [3]

The average photovoltaic efficiency was found to be 8.4 and 8.2% for no load and full load conditions while energy efficiency was 11.4 and 11.2%.

B.L. Gupta et al. [4] has done work on Optimum sizing of PV panel, battery capacity and insulation thickness for a photovoltaic operated domestic refrigerator. A parameter study is carried out to find out the best combination of the PV panel wattage, battery capacity and insulation level to operate the refrigerator stand-alone on solar power. The system consists of a refrigerator with 50 liter capacity, 24 V battery bank, 1 kVA inverter, and PV panels with charge controller. Fig 3 shows the complete experimental setup with major component used. Battery, inverter and refrigerator are kept in a room while SPV is placed on the roof. Charge controller is placed on the wall. The arrangement of the setup is done in such a way that it minimizes the wiring distance thus the loss of power.

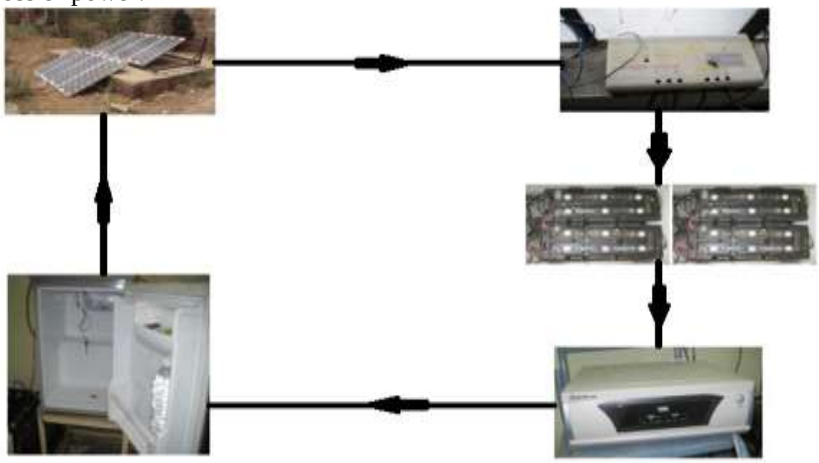

Fig -3 Main components of experimental setup [4]

The results conclude that it is feasible to operate a refrigerator (25 mm insulation thickness) on SPV without grid power with 320W panel arrays with 50 Ah battery capacities. As the thickness of insulation is increased to 50 mm then 200W panel capacity is sufficient to drive the refrigerator.

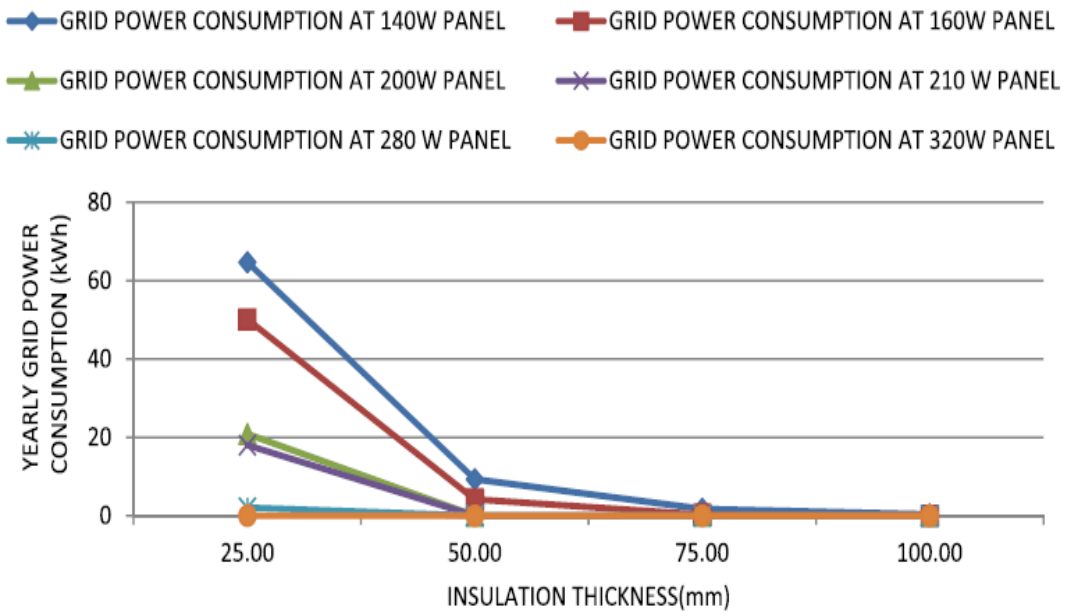

Fig -4 Insulation thickness for different panel wattage [4]

Anish Modi et al. [5] has done work on Performance analysis of a solar photovoltaic operated domestic refrigerator. The fabrication, experimentation and simulation stages of converting a 165 liter domestic electric refrigerator to a solar powered one were done. A conventional domestic refrigerator was chosen for this purpose and was redesigned by adding battery bank, inverter and transformer, and powered by solar photovoltaic (SPV) panels. An old domestic refrigerator (165 L capacity) with the condenser tubes at the back and the compressor

placed at the bottom is used. The refrigerant used in the system is R-134a, the eco-friendly refrigerant most commonly used nowadays. The refrigerator cabinet is divided into three zones – the freezer cabinet (top), the crisper tray (middle) and the lower compartment (bottom). The compressor is placed below the condenser tubes and is visible from the back side of the refrigerator. The rated power of the compressor is 110W and it runs on 50 Hz electricity. The acceptable voltage range for the compressor is 160–250 V. The rated running current is 0.95 A. The thermostat used in the system has markings from 0 to 9 on its control knob: 0 for switching off, and 1–9 for setting up the cutoff temperature at 2 ºC to 18 ºC in the freezer compartment respectively. The thermostat also had a defrost switch. Four 35W SPV panels were used to convert the solar energy into electrical energy.

Variation of temperature at different places with time as compared to the ambient temperature is shown in fig 5. The system under test was able to maintain a temperature as specified by the WHO for vaccine preservation (0–8 ºC).

140W photovoltaic capacity and two 12 V, 135 A h battery bank is the least possible configuration required for this converted system

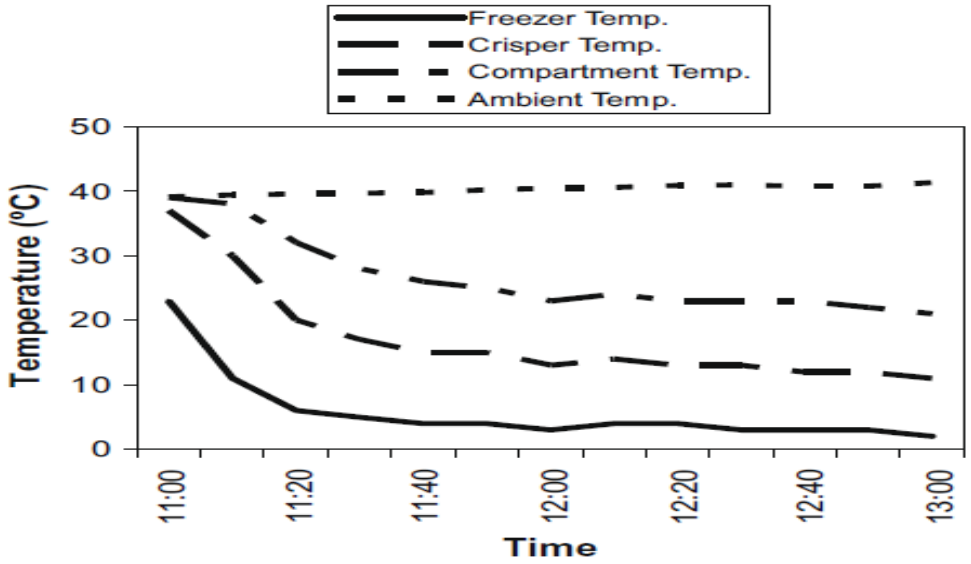

Fig -5 Variation of temperatures at different places with time as compared to the ambient temperature [5]

Socrates Kaplanis at el. [6] has done work on performance evaluation of a modified conventional refrigerator to serve as a PV powered one. A conventional refrigerator was used and some changes were made to reduce the cooling load and consequently the power required. Tests were carried out to study the performance of the refrigerator components and especially the compressor's, as well as the refrigerator as a whole.

1. Two models of conventional refrigerators were examined for conversion to PV powered ones. The first model was the FV650 which has a consumption of 8.8 kW h per day in the Greek environment during summer time. According to a preliminary sizing 22 PV panels of 85 W are required for this model. This product is not economical at all and was given over. The second model, which was examined, was the FV100. This model has energy consumption equal to about 4 kW h per day, according to the company's specifications for the conventional mode of the refrigerator. On the other hand, when it is PV-powered, the daily load is 2.2 kW h. This is due to the modifications brought in, as to be presented below. The nominal power for the PV-powered refrigerator elements is given in Table 1. In contrast to the conventional refrigerator those loads are met by a smaller PV-generator.

2. Three modifications were brought into the FV100 model to decrease the heat losses or equivalently cool loads and to operate the refrigerator, even at low solar insolation.

Table -1 Nominal power of the different components of a refrigerator [6]

Components	The conventional mode of the cooler type FV100 (W)	The PV powered mode of the cooler fan FV100 (W)
Evaporator fan	5	5
Condenser fan	5	5

Compressor fan	Does not exist in this model	2.4
Nominal compressor power	185 W (AC)	143 W (DC)

Modifications:
(a) Increase of the refrigerator insulation of polyurethane by 25 mm. As a consequence the increase of insulation had reduction of the internal volume by 30%.
(b) Replacement of the door's double glass by insulation to reduce the heat losses. This change had as a disadvantage the lack of the internal view to the refrigerator.
(c) A three phase brushless motor with permanent magnet was used in the compressor. This compressor is a DC one with variable speed running from 2000 to 3500 rpm. The type chosen is the Danfoss BD50F. Due to this change no DC/AC inverter was required.
(d) The battery system could be switched on/off during the operation through the control panel.
Results showed that the modifications introduced reduced the useful volume capacity by 30%. This is the only drawback, while on the other hand this modification reduced heat losses, i.e. the cooling load considerably. Hence, energy consumption fell down to 1.53 kWh/day, for refrigeration purposes with a 15 h operation of the compressor, while for conservation the load was 1.7 kW h with the system operating for 24 h.

3. CONCLUSIONS

After referring the literature it can be concluded that large amount of panel wattage will be required for decrease in insulation thickness, conversion of AC motor to DC shows that no inverter is required, Volume capacity decreases with increase in insulation thickness.

4. ACKNOWLEDGEMENT

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