Solar Powered Refrigeration System with Cold Reservoir without Battery

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Abstract— Refrigerated storage, which is believed to be best method for storing the fruits and vegetables in fresh form, is not available in rural or remote locations where grid electricity is almost not available. So, without having a conventional energy source at these areas, the present study was taken up to design and fabricate a solar PV powered vapour compression refrigeration system to attain favourable conditions for potato storage, and to evaluate its shelf life under different operating conditions. It consisted of PV panel, inverter and the vapour compression refrigeration system consists of a drier-cum-filter besides the main components: compressor, condenser, expansion device, evaporator, exhaust and evaporator fans.

Key words: Solar Powered Refrigeration System, MPPT Controller, PV Panels

I. INTRODUCTION

Large parts of developing countries especially rural areas have no access to electricity. From the statistics of India energy outlook, the energy demand for India's 1.3 bill on people has outpaced the growth and some 240 million still have no supply to electricity .Since large population of our country is concentrated at rural areas; constant supply of electric power is usually unavailable, insufficient or unreliable. Even in grid area, the demand for power surpassed the supply growth resulting in power-cut, insufficient supply for refrigeration. Solution for supply of electricity for refrigeration, over the year, is met by generators and batteries as well as absorption type refrigerators which burn kerosene or bottled LPG. Both the solution uses fuel, chemicals which causes pollution and also supply of electricity; from these, suffers supply interruption caused by many reasons, such as cost, fuel shortage, theft, poor planning or diversion to other resource.

Absorption refrigerators have low efficiency, large temperature fluctuation, and frequent maintenance problem, less ice-making capacity which puts limit to refrigeration of perishable goods and cold chain supply for vaccines. In early days absorption devices were primarily used, due to unavailability of other options at a similar cost, and countries anticipated that the electrification of rural areas would be soon, supplying reliable source of energy for compression-type refrigerators. However, minimal consumer loads, and high rising costs for electrification of rural area, it is often not an economical option. As a result, absorption refrigerators are still in use today, in majority of vaccine storage locations, in spite of shortcoming in providing safe and proper storage of vaccines.

Now a day's, solar-powered refrigerators for vaccine or food storage, uses both solar PV panels and batteries to store energy and supply, for night and at cloudy days to run the refrigerator .These fridges are uneconomical and require huge lead-acid batteries which poses maintenance problem and leads to deterioration, especially in hot climates, or are used for other purposes. Batteries usually require constant maintenance, should be replaced every three years, and must be disposed safely; the hazardous waste cause serious problem of lead pollution. Due to environmental pollution concerns and high cost, solar powered refrigerator with batteries becomes an obstacle for usage in developing areas. This causes economic and environmental problems, which is not an encouraging factor to use new technology has to be developed which eliminates the use of battery.

II. REFRIGERATION

Refrigeration is science of cooling, by principle of 2nd law of thermodynamics. We know that heat always flow from high to low temperature potential. But to flow heat from low to high potential, external aid such as work is required to deliver heat. Device that delivers, heat from low to high temperature, producing cooling effect is called refrigerator.

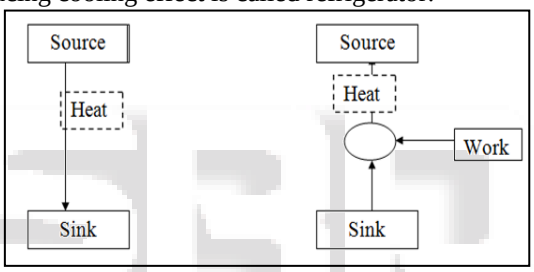

Fig. 2: 2nd Law of Thermodynamics

The refrigerator uses refrigerant as a working medium, heat transfer takes places as a result of phase change. The above figure shows principle behind refrigeration.

III. DESIGN OF THE MODEL

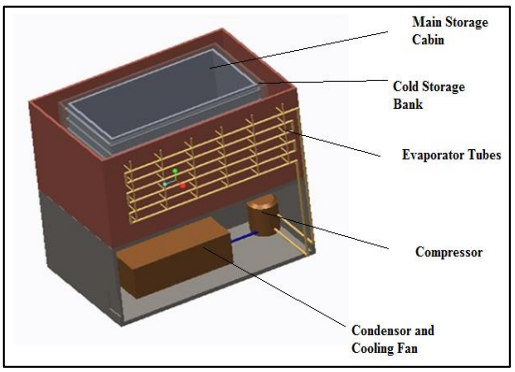

Fig. 3: Isometric View of the Components

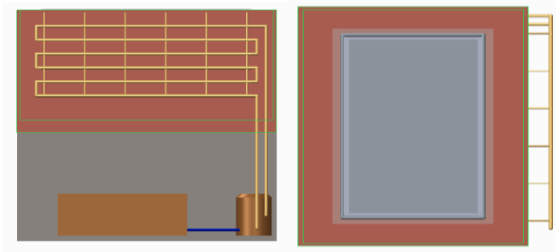

Fig. 3.1: Rare view of model

IV. METHODOLOGY

Design of solar-powered refrigerator with cold bank, provides complex challenges since, the electrical characteristic of the PV panels and AC compressor have to match and provision should be made to run the refrigerator at night, when solar power is unavailable. The aim of the project is to make the system compact and portable, hence it is designed like a domestic fridge. Aqueous solution of Propylene Glycol is used as cold thermal reservoir, which gives refrigeration at night. Also gives constant temperature in the evaporator space caused by intermittence supply of electricity due to clouds. The location of the reservoir should be in optimal distance from the evaporator cabin and tubes. Since the reservoir absorbs heat, well insulation should be accommodated. The isolation is fluctuating a charge controller is needed to control the electricity to the refrigerator. Invertor is used to convert DC current from the panels to AC to power refrigerator. The following deign is proposed for refrigerator with cold storage bank.

V. RESULTS AND DISCUSSION

The assembled unit as shown. The PV panels are arranged in parallel and connected to MPPT controller. The output from the controller in given to refrigerator through invertor. During daytime, the refrigerator is run by solar power which simultaneously cool the cold bank solution. When the no sunlight the cold bank provide the cooling effect.

The testing is carried out with no load and load conditions for complete day. Water and vegetables are stored in refrigerator during testing and reading of cabin temperature with respect to time is recorded. The aim of the testing is to find the time required to cool the cabin to -10º C and duration of time of cooling effect provided by the cold bank when the refrigerator is off. The cold bank is filled with 10L of solution. The refrigerator is started at 9 am and switched off at 4 pm. Every interval of hour the temperature in noted.

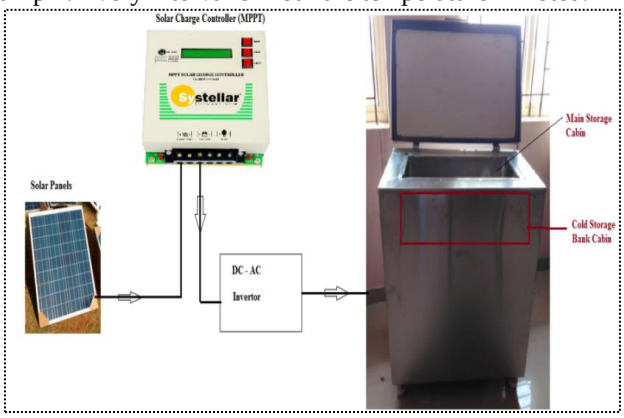

Fig. 5: Assembled View of the Project

The load is chosen based upon the requirement. Water and vegetable with different quantity is chosen for testing. These have different heat capacity hence the reading gives the duration of time taken by the refrigerator to cool to -10ºC. Also once the refrigerator is off, duration of time that cold bank can provide cooling effect for different heat capacities material. Four loads for testing are taken, without any load, with 5L of water, with 5kg of vegetable, mix of vegetable and water and 10L of water.

VI. CONCLUSION AND FUTURE SCOPE

The energy requirement of the world is increasing daily and it has become difficult to meet the demand .especially in rural area where grid connectivity is unavailable. In this regard, a refrigerator is designed, with sole purpose, of running it with solar power and cold bank is provided to give cooling load at night. From the testing, it seen that, for the refrigerator of 150 liters capacity, six solar panels of 75W is sufficient to run on any ordinary sunny day. The COP is the refrigerator is 1.4. It can share the load of the evaporator space and the cold thermal bank. The propylene glycol and distilled water solution in the volume ratio 20:80 can give freezing temperature of -10ºC. 10 litters of the solution can hold the cabin temperature below zero for almost 16 hours which meets our requirements. But as the loads increased the time required to reach -10^{0}C was also in increased. For load of 5L of water and 5kg of vegetable, refrigerator took 4 hours to reach -10^{0}C and cold reservoir bank provided 7 hours of cooling below 0^{0}C.for load of 10L of water and 5kg of vegetable, 5L of water, it took 5½ hour to reach -10^{0}C.cold reservoir provided 7 hours of cooling below 0^{0}C. The cold holding time of the cold bank also decreased with addition of load. But from the results it clear, required temperature and cold holding time of the cold cabin was sufficient for our requirement

The improvement in designed can be made by reducing the No. of solar panels used by making it efficient and preventing heat leakage from the cabin. The freezing temperature of the solution can be dropped further below, by increasing the ratio of the propylene glycol in the solution. The cold bank can operate for a long time if the quantity of solution used is increased. The different phase change material for use of cold bank can be tested to increase holding time as well as reducing freezing temperature. COP of the refrigerator can be enhanced.

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