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Solar Operated Domestic Refrigetator

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Abstract:-: Refrigeration is defined as the process of removing heat from an enclosed space or from a substance for the purpose of lowering the temperature. Refrigeration is closely related to the demand for cooling foodstuffs and many other commodities as a normal part of commercial domestic life. Solar refrigeration is thought of as one of the best alternatives to address this issue and it may be accomplished by using one of the refrigeration systems: vapour compression, absorption or thermoelectric refrigeration system. Before mechanical refrigeration systems were introduced, ancient peoples, including the Greeks and Romans, cooled their food with ice transported from the mountains. Wealthy families made use of snow cellars, pits that were dug into the ground and insulated with wood and straw, to store the ice. In this manner, packed snow and ice could be preserved for months. Stored ice was the principal means of refrigeration until the beginning of the 20th century, and it is still used in some areas. Conventional refrigeration systems use ChloroFluoro Carbons (CFCs) and Hydro Chlorofluorocarbons (HCFCs) as heat carrier fluids. Use of such fluids in conventional refrigeration systems has a great concern of environmental degradation and resulted in extensive research into development of novel refrigeration technologies. 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. Therefore, the ideal solution would be to use some type of renewable energy resource to provide these houses with energy without an expensive electrical grid connection. One solution is a RAPS (Remote Area Power Supply) using an alternative form of energy.

Keywords: Refrigeration, vapour, thermoelectric, energy, temperature, heat.

I. INTRODUCTION

After studying various research papers as mentioned in literature review, we have fond that there is no such refrigeration system which is portable. Due to portability we can take anywhere as per our requirement. Also there are no multiple inputs are available i.e. up-to-date the system either works on photovoltaic system or electrical supply. But there is no provision of both photovoltaic and electrical supply. By providing both inputs we can overcome energy crisis.

Normal functioning of human beings sufficient, protein, carbohydrate, vitamin and salts are requires which accomplish by balance diet or pills. The people with normal health and their peculiar habits prefer tasteful diet to fulfill the normal functioning of body organs requirement. Another necessity of refrigeration is in the developing of certain scientific equipment and their operation under controlled environment to get reliable results. Many industries like chemical, milk dairy, oil refinery, etc. require low temperature to carry various processes. In vapor compression cycle, the refrigerants are used for cooling. Due to leakage of them, the problems are raised like global warming, increase in carbon percentage, ozone layer depletion etc. From research data on the refrigerant's environmental impact it was assumed that there will be a leakage of 15% during the manufacturing process. This is the maximum leakage permitted by the US Environmental Protection Agency.

II. LITERATURE SURVEY

R. Saidur, H.H. Masjuki, M. Hasanuzzaman, T.M.I. Mahlia, C.Y. Tan, J.K. Ooi and P.H. Yoon (2008) they have studied that, a thermoelectric refrigerator which is developed in standalone photovoltaic system for domestic usage has been presented in this paper. The photovoltaic sizing required for efficiently running the thermoelectric refrigerator with energy consumption 520Wh is including 4 solar modules of 5.7A, 17.5V and100W; 4 lead acid batteries of 12V and 100Ah, a solar charge controller of 12A and 24V; and an inverter of 24V and 150W [1].

Manoj Kumar Rawat, Lal Gopal Das, Himadri Chattopadhyay and Subhasis Neogi(2008),they have studied that, the Researchers are continuously giving efforts for development of eco-friendly refrigeration technologies like thermoelectric, adsorption, magnetic and thermo acoustic refrigeration. These kinds of refrigeration systems having limitation of use of grid power and same cannot be utilized for remote applications. The experimental results of developed prototype of TER system shows that the performances were optimum for a given operating conditions I=0.5Imaxi (I=2.0 Ampere & V= 5.5 Volt) and forced air convection heat dissipation presented in this paper [2].

Manoj Kumar Rawat, Himadri Chattopadhyay, Subhasis Neogi (2013), they have studied that the research effort made by different researchers for design and development of novel thermoelectric refrigeration and space conditioning systems has been thoroughly reviewed in this paper. His work explained those thermoelectric cooling materials needed to have high Seebeck coefficients, good electrical conductivity to minimize Joule heating, and low thermal conductivity to reduce heat transfer from junctions to junctions. The calculated COP of developed experimental thermoelectric refrigeration cabinet was 0.1. The available literature shows that thermoelectric cooling systems are generally only around 5–15% as efficient compared to 40–60% achieved by conventional compression cooling system [3].

III. PROBLEM STATEMENT

According to survey of World Health Organization, numerous people are affected by diabetic disease. In diabetes medical survey says that in 2020, 8 crores people will be a diabetic patient in the world. It is specially designed for preserving insulin and other medicines. It may be implementing in the medical field. The paper reports on an effort to develop a portable refrigerator kit using thermoelectric cooling is the solution for maintaining at particular temperature level at any time with low cost. This is most effective for poor people (by the cost) and travelling people (because of size). The project study and experimental analysis of portable refrigerator under study due to following disadvantages of conventional refrigerators. They are bulky, power rating was high. Conventional refrigeration system bigger in size and costly.

3.1 SCOPE

The project designed has wide scope for future applications. The various applications are:

1. Due to compact nature of the system, portable refrigerators can be used for transporting the various food article, ingredients, cold drinks etc.
2. Due to its low weight, it is easy to handle and carry over long distances.
3. It can be also used in storage of medicines and other medical applications.
4. Due to use of solar operated battery, power usage can also be reduced.

IV. EXPERIMENTAL SETUP AND INSTRUMENTATION

a. SETUP

A solar powered thermoelectric refrigeration system consists of many components.
The construction set up (Fig.1) for this system require following parts:-

i. Solar panel

ii. Charge controller
iii. Thermoelectric module
iv. Exhaust fan
v. Cabinet
vi. Battery bank & Relay switch

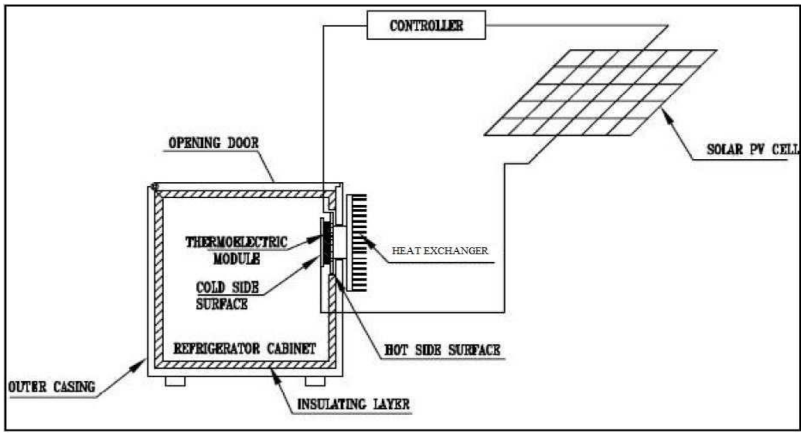

Fig.1 Experimental Setup Diagram

b. SOALAR PANEL

Solar panels are used in order to convert solar energy into dc voltage. Solar panel is a bunch of number of solar cells. This solar cell absorbs energy from sun rays and converts into dc voltage. If the strength of sun rays is more the output voltage is high and it is low when strength is weak.

Fig. 2 Solar panel

That is why output from the solar panel is less in the morning evening and during night hours. And it is maximum at mid-day. Thus, these solar panels convert the non-conventional energy and thus helping in minimizing the shortage in conventional energy. This solar energy sources are used for street lights, laboratory supplies, agricultural farms, solar bikes, water heaters, and house hold electricity.

The solar panel shown in fig.2 are available in varies ratings that is 6v, 12v, 18v, 24v, 40v, etc. and different wattages. Say 500 watts, 1000 watts, 2000watts…..etc. In some cases battery chargers are used for charging the battery but in the applications where the load is not so heavy. The output from solar panel can be directly connected to the dc battery.

DC batteries are charged during the day time and store the energy which is utilized during the hours where there are no sun rays and conventional electricity is not utilized. DC batteries are available in different ratings. The battery we utilized in our case is 12v, 10AH capacity.

In the applications where appliances are operating on AC supply, the battery supply is converted into AC. For this purpose inverters are required. But in our case the motor used is operated on DC supply. So, there is no need of DC to AC converter. Also, if the polarity is reversed the motor direction is changed [1].

- Specifications:-

- Maximum power (P_{max})[3] : 20W
- Voltage at P_{max} (V_{mp}) : 16.8V
- Current at P_{max} (I_{mp}) : 1.19A
- Maximum system voltage : 50V (US NEC rating),50V(IEC 61215 rating)

V. EXPERIMENTAL WORKING

Thermoelectric refrigeration uses the Peltier effect to create a heat flux between the junctions of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). They can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools.

This technology is far less commonly applied to refrigeration than vapor-compression refrigeration. The main advantages of a Peltier cooler are its lack of moving parts or circulating liquid, near-infinite life and invulnerability to potential leaks, and its small size and flexible shape. Its main disadvantage is high cost and poor power efficiency. Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient [4].

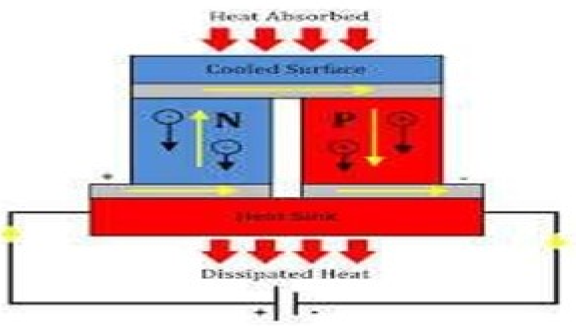

Fig. 3 Peltier effect

A Peltier cooler can also be used as a thermoelectric generator. When operated as a cooler, a voltage is applied across the device, and as a result, a difference in temperature will build up between the two sides. When operated as a generator, one side of the device is heated to a temperature greater than the other side, and as a result, a difference in voltage will build up between the two sides (the See beck effect).

The principle of power generation behind the solar cells consists of the utilization of the photovoltaic effect of semiconductors. When such a cell is exposed to light, electron-hole pairs are generated in proportion to the intensity of the light. Solar cells are made by bonding together p-type and n-type semiconductors. The negatively charged electrons move to the n-type semiconductor while the positively charged holes move to the p-type semiconductor. They collect at both electrodes to form a potential. When the two electrodes are connected by a wire, a current flows and the electric power thus generated is transferred to battery banks connected to it. Solar charge controller is used to supply constant current to batteries. From battery the supply is given to the thermoelectric module which produces refrigeration effect in the cabinet using peltier effect. So required refrigeration effect can be obtained by supplying voltage from battery.

VI. MODULES

i. Thermoelectric module

A typical thermoelectric module is shown in Fig. 4 is composed of two ceramic substrates that serve as a foundation and electrical insulation for P-type and N-type Bismuth Telluride dice that are connected electrically in series and thermally in parallel between the ceramics. The ceramics also serve as insulation between the modules internal electrical elements and a heat sink that must be in contact with the hot side as well as an object against the cold side surface. Electrically conductive materials, usually copper pads attached to the ceramics, maintain the electrical connections inside the module. Solder is most commonly used at the connection joints to enhance the electrical connections and hold the module together.

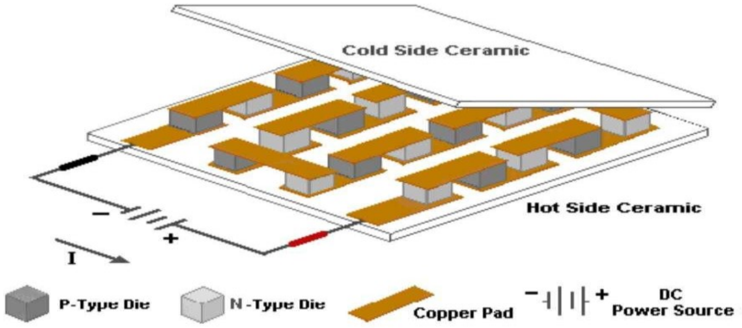

Fig. 4. Thermoelectric module

Most modules have and even number of P-type and N-type dice and one of each sharing an electrical interconnection is known as, "a couple." While both P-type and N-type materials are alloys of Bismuth and Tellurium, both have different free electron densities at the same temperature. P-type dice are composed of material having a deficiency of electrons while N-type has an excess of electrons. As current flows up and down through the module it attempts to establish a new equilibrium within the materials. The current treats the P-type material as a hot junction needing to be cooled and the N-type as a cold junction needing to be heated. Since the material is actually at the same temperature, the result is that the hot side becomes hotter while the cold side becomes colder. The direction of the current will determine if a particular die will cool down or heat up. In short reversing the polarity will switch the hot and cold sides.

ii. Operating principle

Fig. 5. Peltier Effect

The TEM operating principle is based on the Peltier effect. The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material. One of the TEM sides is cooling and the other side is heating. As shown in Fig.5 when a TE module is used, you must support heat rejection from its hot side. If the temperature on the hot side is like the ambient temperature, then we can get the temperature on the cold side that is lower (tens of Kelvin degrees). The degree of the cooling is depended from the current value that is leaking through a thermoelectric module. In a thermo-electric heat exchanger the electrons acts as the heat carrier. The heat pumping action is therefore function of the quantity of electrons crossing over the p-n junction [4].

iii. Temperature Controller

As the name implies, temperature controller shown Fig.6 is an instrument used to control temperature. The temperature controller takes an input from a temperature sensor and has an output that is connected to a control element such as a heater or fan.

Fig. 6. Temperature controller

To accurately control process temperature without extensive operator involvement, a temperature control system relies upon a controller, which accepts a temperature sensor such as a thermocouple or RTD as input. It compares the actual temperature to the desired control temperature, or set point, and provides an output to a control element. The controller is one part of the entire control system, and the whole system should be analyzed in selecting the proper controller.

iv. Heat sink and fan assembly

Fig. 7. Fan Assembly

Fig. 8. Heat Sink

Fan Heat Sinks provide significant component cooling benefits over system level fans. They incorporate a dedicated fan (Fig.7) with a heat sink base to increase localized airflow while improving thermal efficiency. These active fan heat sinks allow for greater thermal performance than can be achieved with an equivalent size passive solution. By matching fan performance to a variety of extrusion or other fabricated fin bases, fan heat sinks (Fig.8) can be designed to meet specific application requirements.

v. Battery Bank

Fig.9. Battery

As shown in fig. 9 batteries are a common feature in most types of PV systems that are not connected to the utility grid. In addition to providing storage.

VII APPLICATIONS and ADVANTAGE

Commercial devices based on thermoelectric materials have come up in a big way recently. In addition to the benefits thermoelectric offer over the conventional devices, commercial factors like decrease in production costs and significant opening of consumer markets have helped it in a big way and the use of T.E. devices is increasing day by day.

- Thermoelectric cooling is used in medical and pharmaceutical equipment, spectroscopy systems, various types of detectors, electronic equipment, portable refrigerators, chilled food and beverage dispensers, and drinking water coolers.
- Requiring cooling devices with high reliability that fit into small spaces, powerful integrated circuits in today's personal computers also employ thermoelectric coolers.
- Using solid state heat pumps that utilize the Peltier effect, thermoelectric cooling devices are also under scrutiny for larger spaces such as passenger compartments of idling aircraft parked at the gate.

Some of the other potential and current uses of thermoelectric cooling are:

1) **Military/Aerospace**

   Inertial Guidance Systems, Night Vision Equipment, Electronic Equipment Cooling, Cooled Personal Garments, Portable Refrigerators.

2) **Consumer Products**

   Recreational Vehicle Refrigerators, Mobile Home Refrigerators, Portable Picnic Coolers, Wine and Beer Keg Coolers, Residential Water Coolers/Purifiers.

3) **Laboratory and Scientific Equipment**

   Infrared Detectors, Integrated Circuit Coolers, Laboratory Cold Plates, Cold Chambers, Ice Point Reference Baths, Dew point Hygrometers, Constant Temperature Baths, Thermostat Calibrating Baths, Laser Collimators.

4) **Industrial Equipment's**

   Computer Microprocessors, Microprocessors and PC's in Numerical Control and Robotics, Medical Instruments, Hypothermia Blankets, Pharmaceutical Refrigerators - Portable and Stationary, Blood Analyzers, Tissue Preparation and Storage, Restaurant Equipment, Cream and Butter Dispensers.

➢ ADVANTAGES

Thermoelectric cooling devices and systems are believed to be as good as compressor- or absorber based refrigerators. However we believe that thermoelectric cooling offers a number of advantages over traditional refrigeration methods, namely:

1) Solid state heat pumps have no moving parts
2) No Freon's or other liquid or gaseous refrigerants required
3) Noiseless operation
4) Compact size and light weight makes TEMs well suited for miniature coolers
5) High reliability - We guarantee 200,000 hours of no failures
6) Precise temperature control
7) Relatively low cost and high effectiveness
8) Operation in any orientation
9) Easy to clean aluminum interior
10) Eco-friendly C-pentane, CFC free insulation
11) Lower starting power

CONCLUSION

Thermoelectric refrigerators are greatly needed, particularly for developing countries, where long life, low maintenance and clean environment are needed. In this aspect thermoelectric cannot be challenged in spite of the fact that it has some disadvantages like low coefficient of performance and high cost. These contentious issues are the frontal factors hampering the large scale commercialization of thermoelectric cooling devices.

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