Design of Solar Energy Based Refrigerator

Anand M. Sharan

Abstract— **The paper discusses two types of refrigerators - one using thermos-electric elements which cause cooling to take place when electricity is passed through these. The needed electricity here is generated using an efficient electrical conversion of Sun's energy into electricity using photo-voltaic panels by tracking the Sun as one option. Alternately, the solar panel can be fixed. The second method of cooling is by using an eco - friendly refrigerant. The comparison of results is carried out in terms of lowest temperature achieved, and the energy consumption.**

I. INTRODUCTION

The history of mankind has depended upon man's ability to tame and conquer the forces of nature and to utilize these forces to serve his needs. In this respect, man has made regular advances in the harnessing of energy. The ability to utilize fire was one of the greatest breakthroughs of all human pre-history. The invention of the steam engine by James Watt brought about the development of large factories, steamships and the steam locomotive. As a fuel, at first wood was used, then coal. About the same time, the use of coal led to advances in metallurgy, which made possible the production, of large quantities of cheap steel and copper. This was the beginning of the Industrial Revolution. In the beginning of last century, oil came as a major player as a source of energy.

All of these developments came with a price to pay for the humanity. It came with tremendous cost - in terms of environmental damage due to the burning of coal, and fossil fuels. The combination of power generators and auto industry - are the major sources of pollution.

II. GLOBAL WARMING, ACID RAIN, AND DAMAGE TO OZONE LAYER

We have actually kept a record of what the atmosphere has been on this planet for the past 150,000 years. It comes from boring very deep, say 500 feet down into the ice caps in Greenland, Antarctica and the glaciers of the Himalayas and then analyzing carefully the air trapped between the snowflakes that fell. This was compacted to the ice formed thousands of years ago. Scientists are satisfied that this is safe data.

The Inter-Governmental Panel on Climate Change had comprehensively reviewed global warming and had reached a consensus in 1995, that the phenomenon (global warming) was real and poses a significant environmental threat, if fossil fuel use continues at the present global levels. According to the panel - to stabilize the carbon dioxide concentration in the atmosphere at the present levels, a 50-80 per cent reduction in all emissions would be required.

Scientists have predicted a rise of the earth's temperature-about 0.2 degree C every decade-and resulting in higher sea levels, as oceans expand and glaciers melt - about 50 cm by 21st century. Scientists also fear that there may be unpredictable climatic changes when there will be droughts, storms and floods.

Gases like Sulphur dioxide and nitrogen oxides resulting from the use of fossil fuels and these are converted into sulphuric acid and nitric acid respectively by oxidation in the air and drop down as rain and snow--called Acid Rain-to pollute the earth. They leach out toxic elements like mercury, and cadmium and other metals which pollute the water bodies, kill fish, cause forests to die and they cause soil to erode. Unpolluted rain has a pH of roughly 5.6. One can look into the reference section of this paper to get some idea about the damage to the environment by sulphuric acid and nitric acid or to the ozone layer.

In the Glasgow Conference held in November, 2021, the representatives from 200 countries agreed to (a) cut carbon emissions, (b) phase out some fossil fuels, and increase aid to poor countries on the front lines of climate change [1].

There have been certain chemicals such as Freon 12, a refrigerant, which rise to the highest levels in the earth's atmosphere, and damage the protective ozone layer which keeps the ultra violet light from the Sun from reaching the earth. This light causes skin cancer, and affects the eyes.

In view of the above, we should be selecting a proper form of energy source other than the fossil fuels, and utilize them in an optimal way.

In the present work, the energy is derived from the Sun using photovoltaic panels which track the Sun with minimum energy consumption [2, 3]. This energy can be used to power a cooling / refrigeration system. Alternately, one can use regular supply of electricity where the line voltage of 220/110 Volts AC is converted to a 12 Volt DC.

In this respect about climatic change, can see other works of different in {4-9].

III. ALTERNATE METHODS OF REFRIGERATION / COOLING

I. Thermo-Electric Refrigeration

Refrigeration is a process of pumping heat energy out of an insulated chamber in order to reduce the temperature of the

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chamber below that of the surrounding air. Thermo-electric refrigeration uses a principle called the Peltier effect to pump heat using electricity. The Peltier effect is named after a French scientist who discovered this effect in 1834. In this year Jean Peltier noted that when an electrical current is applied across the junction of two dissimilar metals, heat is removed from one of the metals and transferred to the other. This is the basis of thermo-electric refrigeration. Now a days, the semiconductors have replaced the metals because of their higher efficiency.

Thermo-electric modules are constructed from a series of tiny semiconductors which are physically bonded together on a ceramic substrate and connected electrically. When electrical current passes through the junctions -heat is transferred from one type of semiconductor to the other.

Solid-state thermos-electric modules are capable of transferring large quantities of heat when connected to a heat absorbing device on one side and a heat dissipating device on the other. Here, a small fan (blower) helps to disperse off the heat into the air as shown in Fig. 2.

The system is totally environmentally friendly and contains no hazardous gases, nor pipes nor coils and no compressor. The only moving part is the small 12-volt fan./ blower

They are ideally suited to low thermal energy cooling applications because they are lightweight, compact, and insensitive to motion or tilting, have no moving parts, and can operate directly from12-volt batteries.

Fig. 1 shows the schematic of a thermos-electric cooler system drawing its energy from the Sun through a photo-voltaic solar panel which is mounted on a tracking system. The details of the tracking system are shown in Figs. 5, and 6 [2,3]. By following the Sun, one makes sure that the Sun's rays fall perpendicular to the solar panels and thereby converting the solar energy into electricity in a maximum way. In Fig 5 or Fig. 6, the inner frame holds the solar panel. This inner frame makes an angle with respect to the outer frame equal to the declination of the Sun on a particular day. Since the declination changes very slowly, this angle can be changed once a day. The outer frame - using the motor-gear system is rotated at the same rate as that of the earth which is about 15 degrees per hour. This rotation is done to keep the Sun’s rays perpendicular onto the solar panel.

In order to increase its efficiency, the cooling system was kept inside an insulated chamber as shown in Fig. 2. The chamber has a blower- semiconductor system. In this way, the heat flow from inside is pumped out. The current flow was, on an average, 3.2 amperes at 12 volt supply. Fig. 3 shows a refrigerator having R 134A refrigerant.

The temperature variations - outside (ambient), and inside the inner chamber, are represented by TO, and TI respectively, and are shown in Fig. 4. It took approximately 250 minutes to get to the minimum temperature of 7.3 degrees C. Once it reaches this temperature then one can store food, medicines etc. at this temperature. This is low enough temperature where one can safely keep the perishable items for many days. The electric current needed to maintain the temperature was 3.2 Amperes, which is not high for a 12 Volt system.

1.1 Advantages Of Thermoelectric Refrigeration

Some of the characteristics of this type of refrigerator are:

1. COMPACT SIZE: Very little space is required by the cooling system. The thermos-electric module is of the size of a matchbook.
2. LIGHTWEIGHT: These are lightweight as compared to a regular refrigeration unit .
3. PORTABLE: One can carry these with one hand and are unaffected by motion or tilting.
4. LOWER PRICE: 20% to 40% less expensive than compressor or absorption units.
5. LOW BATTERY POWER REQUIREMENT: It requires approximately 3.5 amperes at 12 Volts.
6. PERFORMANCE: These coolers maintain cool temperatures in ambient up to 32 degree C

1.2 Refrigeration Using Environmentally Friendly Refrigerant

Fig. 3 shows Model F-86 Koolatron freezer / cooler which consumes about 30 Watts (2.5 Amperes at 12 Volt supply). It uses R 134A refrigerant. Its cooling capacity is much faster than the thermo- electric type discussed above. It cooled to - 4 ^{o} C from 23 ^{o}C in 14 minutes.

Obviously, it is far more energy efficient than the thermos-electric one but its disadvantages are weight, moving parts, cost etc. . Its higher operating temperature can be as high as 48 ^{o} C when the perishable items can still be at the freezing temperature of water.

IV. Conclusion

In this work, two types of cooling systems were studied. The first one was based on the Peltier effect where semiconductor elements were used to pump out heat from the cooled chamber.

The second method was using a user friendly refrigerant. The second method was more energy efficient but certain advantages of the first method were also outlined here.

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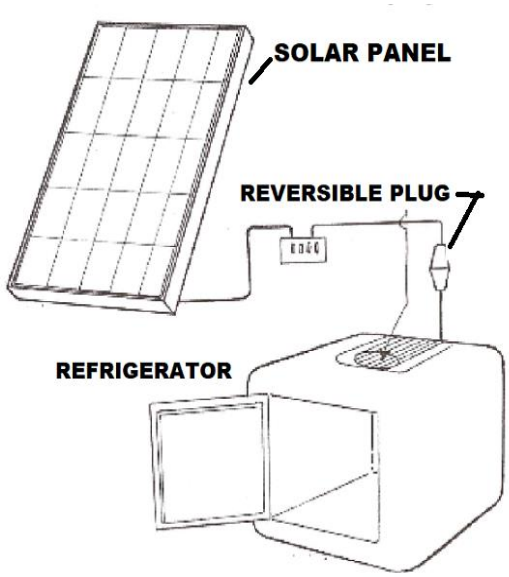

FIG 1 SOLAR PANEL AND REFRIGERATOR

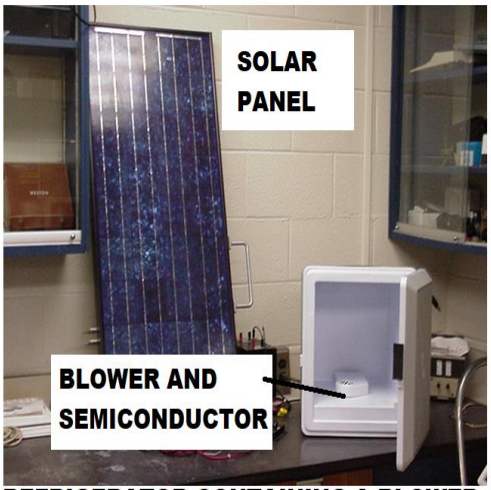

FIG 2 REFRIGERATOR CONTAINING A BLOWER WITH THERMO-ELECTRIC SEMICONDUCTORS

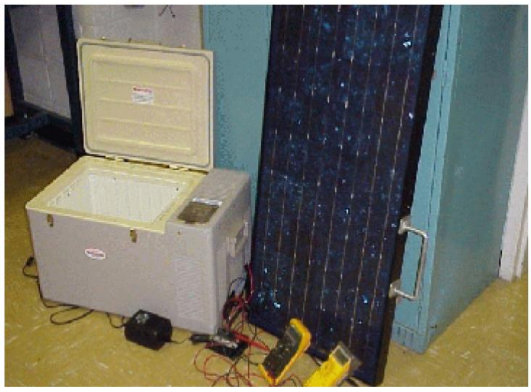

FIG 3 REFRIGERATOR WITH R 134 REFRIGERANT

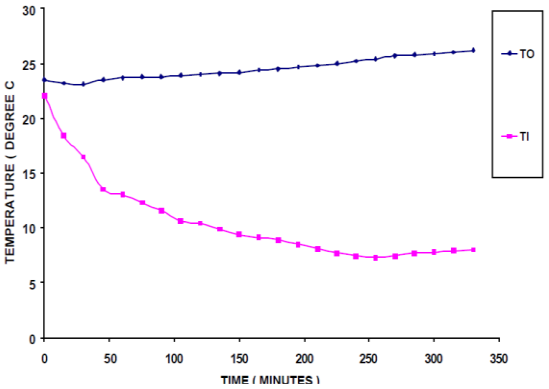

FIG. 4 TEMPERATURE VARIATION IN THERMO-ELECTRIC REFRIGERATOR

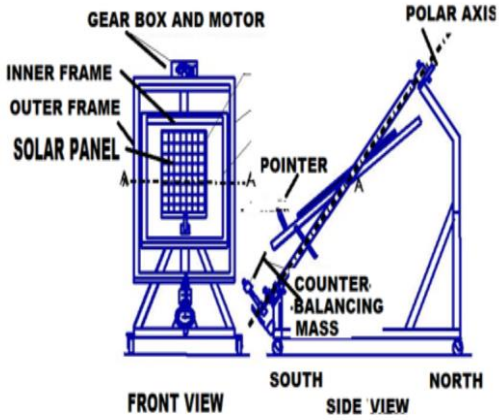

FIG 5 SOLAR TRACKING SYSTEM

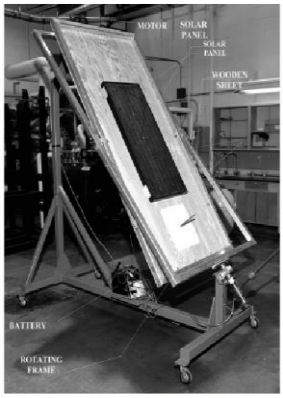

FIG 6 PHOTO OF A SOLAR TRACKING MACHINE