A Refrigerator without Compressor Powered by Solar Energy

Pankaj Kumar Yadav[1], Ashutosh Rai*[2] and Awdhesh Gupta[3]

1. Assistant Professor, Department of Mechanical Engineering, SMS, Lucknow, UP, India. e-mail : yadav.pankaj21@gmail.com
2.* B. Tech. Student, Department of Mechanical Engineering, SMS, Lucknow, UP, India, e-mail : ashurai9661@gmail.com
3. B. Tech. Student, Department of Mechanical Engineering, SMS, Lucknow, UP, India. e-mail : awdheshgupta1700@gmail.com

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***Corresponding author :**
Ashutosh Rai
e-mail : ashurai9661@gmail.com

Abstract

Thermoelectric refrigerator with an inner volume of 10 litre (approx.) has been designed and tested, whose cold system is composed of a Peltier and a fan (i.e. heat sink).Analysis of a its performance in different conditions has been carried out with this prototype.

Thermoelectric devices are capable of converting electrical energy into thermal heat pumping at a very high efficiency.The cooling system is made up of one thermoelectric device, composed of a Peltier module (40 watt) with its hot side in contact with a heat sink and aluminum plate in contact with the cold side.

1. INTRODUCTION

Origin of Proposal the prices of energy have been increasing exponentially worldwide. Industrial Refrigeration is one of the most energy consuming sector. What if a refrigeration system is designed which uses no energy or minimal amount of energy? The solution lies in absorption refrigeration system. By producing an adsorption refrigeration system we are not only cutting down the energy costs but also preserving our environment. This refrigeration system doesn't use any of the CFCs so our ozone layer is safe. Greenhouse gases and their damaging effects on the atmosphere have received increased attention following the release of scientific data by United Nations Environment Programme and World Meteorological Organization that show carbon dioxide to be the main contributor to increased global warming (UNEP, 1991). The domestic refrigerator-freezers operating on alternative refrigerants such as HFC- 134a, contribute indirectly to global warming by the amount of carbon dioxide produced by the power plant in generating electricity to operate over a unit over its lifetime. This contribution is nearly 100 times greater than the direct contribution of the refrigerant alone. Moreover, approximately 62 million mew units are being manufactured worldwide every year, and hundreds of millions are currently in. use.(UNEP,1995) it is anticipated that the production of refrigerator-freezers will substantially increase in the near future as a result of the increased demand, especially in the developing countries. Therefore, in response to global concerns over greenhouse resorts are being made to produce refrigerator-freezers with low energy consumption. In most of the developing third world, adequate supplies of drinking water and water for irrigation are a scarce commodity. In many places in Africa, India and Central and South America, adequate supplies of water are found only at considerable depth below the surface. These locations generally do not have the infrastructure to provide an electrical grid to pump the water with electricity nor do they have the infrastructure to provide roads to bring in electrical generators or even the fuel for those generators. Therefore, without an electrical grid or withoutgenerators to generate electricity, isolated areas do not have potable water nor do they have the refrigeration to keep medicine or foodstuffs from spoiling. Even in the United States, there are communities such as the Amish communities where electricity is banned. Here the lack of cooling capabilities severely limits the production of various products. Because of the lack of cooling, milk production is limited to Grade B. Referred to as advanced adsorption chillers they represent one of the new technology options that are under development. Advanced adsorption cooling technology offers the possibility of chillers with greater COPs and reduces cost of the system. The invention can improve refrigerating unit, raise coefficient of performance, reduce energy cost of refrigerating unit and has notably social and economic benefit. Compared with the existing compressor refrigeration system, the system realizes simplified structure, low energy consumption and reduction of discharge Compared with the existing compressor refrigeration system, the system realizes simplified structure, low energy consumption and reduction of "discharge and environmental pollution by hazardous substance".

2. HISTORICAL BACKGROUND

The current practice of solar-powered intermittent absorption refrigeration is exemplified in U.S. Pat. No. 4, 744, 224. This technology is simple, robust, and reliable. It meets the needs of lesser developed countries by being locally manufacturable and by producing ice at about one-tenth the cost of production by photovoltaic refrigerators, for ice capacity in the range of 10 to 1000 kg per sunny day.

Nevertheless, there still remain two limitations in the current practice of solar absorption refrigeration which have limited its spread. As with all solar technologies, high first cost is a problem. Any measures which would either increase the solar aperture or increase the overall collection efficiency without increasing cost would have the beneficial effect of lowering the first cost per unit of ice produced. Secondly, the inherent functioning of solar intermittent absorption refrigerators is to produce ice at night, which requires evaporator temperatures on the order of -10 degree C and then use stored ice by day to keep the cold box at slightly above 0.degree. C. In other words, the evaporator region inherently cycles between about -12.degree C. and about +4 degree c, depending on isolation and insulation. Clearly it would be possible to incorporate a separate thermostatted compartment cooled by storage ice which maintains a relatively constant +4.degree C and that would be useful for many refrigeration applications. However, there is another category of applications which require a relatively constant - 20.degree. C. This is the temperature of the frozen food section of most domestic refrigerators, i.e., the "freezer compartment." Examples of commodities which require this level of refrigeration for long term storage include oral polio vaccine, measles, and yellow fever vaccines. Although conventional intermittent absorption cycles could easily be adjusted to yield -20.degree. C. at night, at some loss in efficiency, they have no practicable mechanism for maintaining that temperature by day. Multiple-staged absorption cycles are well-known in the art, especially for continuous cycles. See for example U.S. Pat. Nos. 4,402,795 and 4,475,361. Some previous work has also been done on intermittent cycles with multiple stages, for example the technical article by A. Mani and A. Venkatesh appearing at p. 271 of Vol. 26 No. 3/4 1986.

Energy Conversion and Management entitled "A Two Stage Intermittent Solar Refrigeration System—Evaluation of Salient Parameters". In that article, a two-stage generator and absorber configuration is disclosed which enables use of much lower heat source temperatures (approximately 70.degree. C.), albeit at much lower Coefficient of Performance.

The capital cost problems relating to aperture size and collection efficiency stem from two constraints. First is the sidereal motion. The elevation angle of the sun at solar noon changes by 46.5.degree. Through the course of the year. At three hours either side of solar noon, the change is about 5820. Secondly, the inherent functioning of the intermittent absorption refrigeration cycle requires average temperatures on the order of 50.degree C above ambient and afternoon peak temperatures some 15 degree C higher. The collection efficiency of flat plate collectors is simply too low at those temperatures. It is known that as the collection temperature increases, a concentrating collector (solar aperture larger than solar target) becomes more efficient than a flat plate collector. The decreased loss due to heat leakage from the smaller target offsets the increased loss due to reflections. In the technical article "Low Concentration CPC's for Low-Temperature Solar Energy Applications", February 1986, Journal of Solar Energy Engineering, Vol. 108 p. 49, J. M. Gordon shows that a truncated CPC with acceptance half angle of 30.degree. Becomes more efficient than a flat plate collector at 21K above ambient for a concentration ratio (CR) of 1, and at 36K for a CR of 1.5.

Clearly at the temperatures required for solar absorption refrigeration some degree of concentration is appropriate. However, just as clearly the cost and reliability constraints eliminate any use of automatic tracking concentrators. Winston (U.S. Pat. No. 4,002,499) has shown that with a full CPC geometry the concentration ratio achievable from a stationary collector is 1/sin .theta., where .theta. is the acceptance half angle. Unfortunately the full CPC geometry is very wasteful of reflective material—much of it is shaded for much of the year. When the CPC is truncated to avoid shading, the CR attainable at a given acceptance half angle is much lower. If the aperture of a truncated CPC is increased to get more CR, the acceptance angle decreases, thus either missing some sun or requiring tracking.

It is known to increase the solar aperture by adding one or more hinged reflectors to an array, where the hinges are seasonally adjusted. For example, U.S. Pat. No. 4,371,623 discloses addition of hinged flat plate reflectors to a flat plate collector.

What is needed, and one object of this invention, is a solar energy collector which achieves the advantages of a stationary truncated CPC collector without the attendant disadvantage of low CR. Preferably any required seasonal repositioning of such a device would readily be accomplished by one person. Also desirable objectives are that the same geometry be applicable at different latitudes, and that the collector be acceptably storm-resistant.

A second needed improvement, and object of this invention, is a simple add-on to a solar intermittent absorption refrigerator which would allow maintenance of continuous -20 degree C Temperature, preferably without requiring an additional generator.

3. LITERATURE REVIEW

Solar energy applies energy from the sun in the form of solar radiation for heat or to generate electricity. Solar powered electricity generation uses either photo voltaic or heat engines (concentrated solar power).

A partial list of other solar applications includes space heating and cooling through solar architecture, day lighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy.

Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light

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dispersing properties, and designing spaces that naturally circulate air.

India is densely populated and has high solar insulation, an ideal combination for using solar power in India. Much of the country does not have an electrical grid, so one of the first applications of solar power has been for water pumping; to begin replacing India's four to five million diesel powered water pumps, each consuming about 3.5 kilowatts, and off-grid lighting.

Some large projects have been proposed, and a 35,000 km² area of the That Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 Gigawatts.

The Indian Solar Loan Programme, supported by the United Nations Environment Programme has won the prestigious Energy Globe World award for Sustainability for helping to establish a consumer financing program for solar home power systems.

Over the span of three years more than 16,000 solar home systems have been financed through 2,000 bank branches, particularly in rural areas of South India where the electricity grid does not yet extend.

4. SPECIFICATION

Volume:
10 liters (Approximately)
Voltage:
DC 12V; AC 180-240V
Power Consumption:
DC: Cold Mode: 58W+/-20%
Cooling Capacity:
7°C-14°C below ambient temperature
Heating Capacity:
+65°C
Insulation:

Adopts thermoelectric technology (peltier system) solid polyurethane foam with CFC-free Features: One peltier is fixed in the box so that it can cool.

5. SCOPE OF FUTURE WORK

1. COP: We aim to improve the COP of the adsorption/absorption refrigerator to make it more attractive for usage.
2. Size:We aim to reduce the size of the assembly by making it more compact.
3. Weight:The absorption/adsorption refrigeration system is too bulky. Its weight reduction is also one of the aims. It can be reduced by using polymers.
4. Cost: Cost is the biggest barrier in implementation of Adsorption/absorption refrigeration. We aim to minimize it as far as possible.
5. Extended Usability:Till date absorption refrigeration is limited for industrial purposes. We aim to make it available for mass rural use as stated above in small capacities by using solar adsorption/absorption.

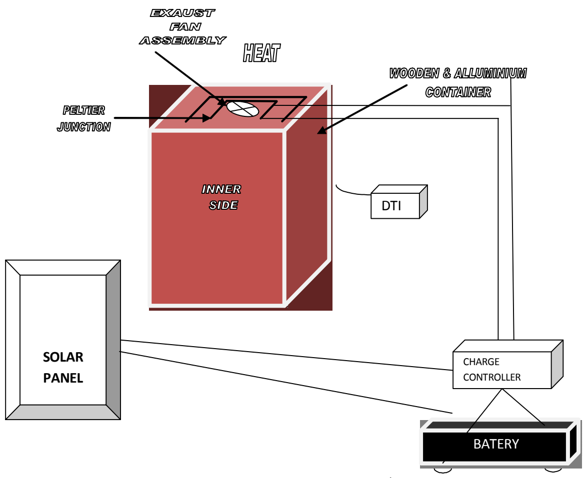

Fig.1: Solar Powered Panel

6. CONCLUSION

A thermoelectric refrigerator with an inner volume of 10litres has been designed and built. Following advantages with respect to vapour compression:

A more ecological system because it does not use refrigerants.

More silent and robust since it minimizes the moving parts (it does not need a compressor).

The disadvantage of the solar refrigerator is that the production of power is not uniform since solar energy is not available throughout the day and it also changes in intensity during various times of the year. Hence, it can be used only in places where strong sun rays are available throughout the year and most parts of the day.

REFERENCES

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