FOOD PRESERVATION REFRIGERATION SYSTEM

K. Bharath Kumar Reddy, M. Tech Student, Department of Mechanical Engineering, Refrigeration and Air Conditioning, Jawaharlal Nehru Technological University Anantapur, College of Engineering (Autonomous), Ananthapuramu, Andhra Pradesh, India.
Dr. K. Kalyani Radha, Assistant professor, Department of Mechanical Engineering, Jawaharlal Nehru Technological University Anantapur College of Engineering (Autonomous), Ananthapuramu, Andhra Pradesh, India.

Abstract
Although, claim to live in a modernistic world today, there are still several places on earth that have relatively been left untouched by civilization. These places don't have access to several facilities, tending to take for granted. One of them happens to be electricity without which the people of these regions face innumerable issues, including lighting, heating, cooling and food preservation, etc. In most cases, lack of access to these resources leads to food wastage on a large scale in these areas. To overcome this problem, developed a proposed system that can rum without electricity. The main aim of the project is to invent a cooling device that can cool without electricity.
Keywords: Air tube, Copper coil, chamber

1. Introduction

This refrigerator has been designed for the sole purpose of food preservation in those areas that have limited access to electricity and money. The refrigerator has taken into account several cues from nature to help preserve foods in cool surroundings. This, in turn, will help prevent food wastage and ensuing malnutrition in several developing countries.

A solar-powered refrigerator is a refrigerator which runs on electricity provided by solar energy. Solar-powered refrigerator 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. In developed countries, plug-in refrigerators with backup generators store vaccines safely, but in developing countries, where electricity supplies can be unreliable, alternative refrigeration technologies are required. Solar fridges were introduced in the developing world to cut down on the use of kerosene or gas-powered absorption refrigerated coolers which are the most common alternatives. They are used for both vaccine storage and household applications in areas without reliable electrical supply because they have poor or no grid electricity at all

This project uses solar energy to run this project. Solar energy is obtained stored into to the rechargeable battery through charging circuit and this battery power is uses to run this project.

2. Literature Survey

M. M. Hussain, et al. [1]: The simulation of thermal energy storage (TES) system for HVAC system has been dealt with in this paper. To store cooling capacity, TES system is integrated with conventional HVAC system. Ethylene Glycol is used as a storage medium in this system. Exergy and Energy analyses have been used to determine the thermodynamic performance of the system. Effect of various parameters such as ambient temperature, cooling load and mass of storage on the performance of the TES system has been also studied in this paper. The results of various studies and analyses conducted on TES systems revealed that the storage temperature decreases linearly with time when there is no load and follows the load profile during daytime and decreases linearly with time at the end. Also, it was found out that the storage temperature decreases slightly with increase in ambient temperature when there is no load. COP of the system was found out to decrease sharply with small increase in storage temperature. It was also discovered that for all mass flow rates of discharging fluid, the energy efficiency of the system was found out to be nearly 80%. But, the exergy efficiency of the system decreased with increase in mass flow rate of the discharging fluid and increased with increase in reference temperature.

Fakeha Sehar, et al. [2]: In this paper, the impact of ice storage systems on the chiller energy consumption for large and medium-sized office buildings in diverse climate zones has been investigated. The various studies indicated that the systems with ice thermal storage (ITS) have higher chiller energy consumptions than the conventional non-storage systems because of the day and night operation of the chiller. By discharging ice storage during the peak hours, the ITS were able to achieve peak energy savings by reducing or even by completely eliminating the chiller operation during the daytime. It was also noticed that climatic zones with summers having high temperatures and relative humidity (RH) increase not only the building cooling load but also the chiller energy consumption by decreasing the cooling intensity of the condenser water, for example-Miami and Las Vegas. But, climate zones with less extreme summers have lower chiller energy consumption due to lower building cooling loads and more cooling of condenser water, for example-Seattle.

Mehmet Azmi Aktacir, [3]: In this study, a PV-powered multi-purpose refrigerator system has been erected to investigate experimentally its daily and seasonal operating performances based on semi-arid climatic conditions of Sanliurfa province in Turkey. It is one of the sunniest rural regions in the world and hence the need for refrigeration is critical. The overall results revealed that PV-refrigerator system can be reliably used in places where the local grid was unreliable and the refrigeration need is critical. On observation, the following results were observed- Low temperature of 10.6°C was reached in the refrigerator, the highest energy amount produced by PV panels was recorded between 11:00 am and 14:00 pm, amount energy consumed by the refrigerator was determined to be 347.7 Wh/day, the amount of energy stored in the battery bank was 78.2 Wh/day while the amount of electric energy produced by photovoltaic panel was 425.9 Wh/day.

3. Implementation

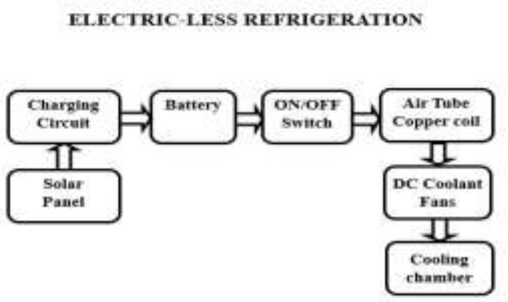


Figure 1

The main aim of the project is to design an electric less refrigeration system using copper coil and air tube along with the cooling device which works without any electricity. Solar energy is treated as nonrenewable source of energy.
This already starts to cool down the air before it's fed into coiled cooper pipe that’s been immersed in water in the evaporation chamber. The evaporation process is helped along by a small, solar-powered DC Fan.
The water evaporating around pipe chills the air inside and this is then fed back underground before entering the refrigeration chamber.

4. Experimental Equipment

The brief introduction of different modules used in this project is discussed below:

ISSN: 2278-4632
Vol-13, Issue-04, No.03, April : 2023

SOLAR PANEL:

Figure 2

Solar power systems employ photovoltaic cells to convert the radiant energy of sunlight directly into electrical energy. Photovoltaic solar cells are semiconductor devices which convert sunlight into electricity. Solar cells which utilize crystalline semiconductors, such as silicon, offer the advantages of high performance and reliability. Photovoltaic cells are silicon-base crystal wafers which produce a voltage between opposite surfaces when light strikes one of the surfaces, which surface has a current collecting grid thereon. The photons of the light are absorbed by photovoltaic cells and yield their energy to the valence electrons of the semiconductor and tear them from the bonds that maintain them joined to the cores of the atoms, promoting them to a superior energetic state called conduction band in which they can move easily through the semiconductor.

Typically, a plurality of solar cells are assembled and interconnected so as to form a physically-integrated module, and then a number of such modules are assembled together to form a solar panel. Several solar panels may be connected together to form a larger array. The individual photovoltaic cells in a module may be connected in series or parallel, typically by an internal wiring arrangement and similarly two or more modules in a panel may be connected in series or parallel, depending upon the voltage output desired. Solar cells are usually interconnected into series strips by electrically interconnecting a collector pad on the grid to the opposite surface of the adjacent cell in the strip. Photovoltaic cells are manufactured in a variety of configurations, but generally comprise a layered structure on a substrate. There are many different types of converging solar cell modules in which sunlight is converged by means of a lens system so that the total area of expensive solar cells can be reduced in order to reduce the cost of electric power generating systems using these solar cells. In order to most efficiently use the electrical power generated by a photovoltaic cell or photovoltaic array, it is desirable to maximize the power generated by the photovoltaic cell or photovoltaic array, despite varying weather conditions. Various sun tracking systems have been used to enhance the power generating efficiency of the converging solar cell module.

Copper tube:

Figure 3

Copper tube is one of the components that is needed in air conditioning and refrigerant system. The tube is used as a path for the refrigerant to flow between system components and to contain it from escaping to the atmosphere. Sizing, installation layout and fittings must be done properly to ensure that the system runs efficiently.

During installation, it is of utmost importance that moisture, dirt and other contaminants are prevented from entering the system. These foreign particles will affect the performance of the system and may even cause damage to some of the components.

During the production of the copper tube, the inside of the tube has been cleaned and dried before being sealed at both ends to ensure that it remains that way. You must check to make sure that the refrigerant that is going to be used does not react with the copper. Ammonia refrigerant will react with copper hence it should not be used. Instead, the stainless steel tubing type will have to be used.

Heat exchangers:

Heat exchangers are devices that transfer heat in order to achieve desired heating or cooling.

Copper and aluminum are used as heat sinks and heat pipes in electronic cooling applications. A heat sink is a passive component that cools semiconductor and optoelectronic devices by dissipating heat into the surrounding air. Heat sinks have temperatures higher than their surrounding environments so that heat can be transferred into the air by convection, radiation, and conduction

Copper heat sinks are die-cast and bound together in plates. They spread heat quickly from the heat source to copper or aluminium fins and into the surrounding air.

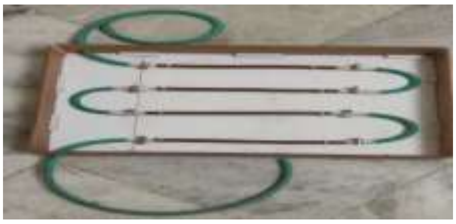


Figure 4

In industrial heat exchangers, hybrids of the above flow types are often found. Examples of these are combined crossflow/counterflow heat exchangers and multi pass flow heat exchangers. (See for example

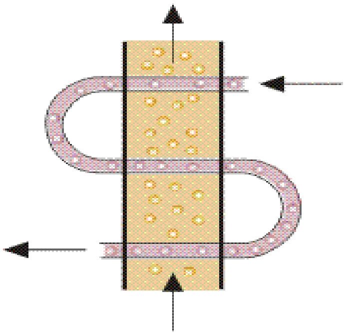


Figure 5

Exhaust Fan

Figure 6

ISSN: 2278-4632
Vol-13, Issue-04, No.03, April : 2023

Exhaust fans work by sucking hot or humid air out of a small, localised area, allowing fresh air to enter from elsewhere (perhaps a doorway or vent) in order to replace it. The warm air that's drawn out using an **exhaust fan** is then pulled through a ducting system and expelled outside.

Food Preservation Refrigeration System:

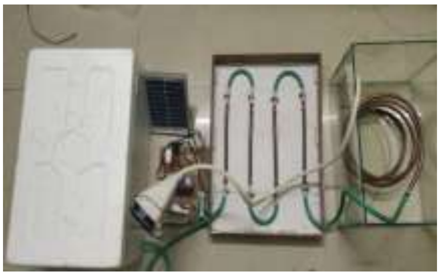


Figure 7

Thermocol is a good insulator and a bad conductor of heat. When ice is kept in it, it does not allow the coldness of it to get away and radiates the coldness back into it.

Measurements:

copper tube.....1feet,4

cooling box.....22.5x18x12 inch

solar panel ....13x14 inch

copper coil.............3 meters

Results:

FRUITS STORAGE DURATION in our Refrigerant:

Refrigeration stored temperature is 18°C (64.4°F),

At this 18°C Mangoes can last for about 3 days.

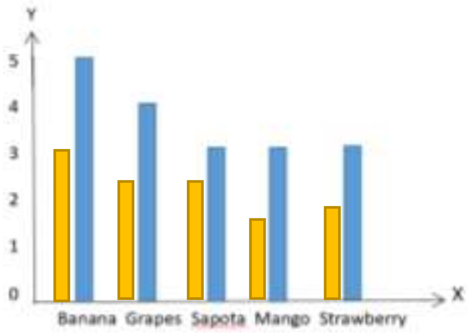
At this 18°C Grapes can last for about 4 days.

At this 18°C Sapota/Chikoo can last for about 3 days.

At this 18°C Bananas can last for about 5 days.

At this 18°C Strawberries can last for about 3 days.

Graph between different fruits and there preservation time (in No. of days) in Food Preservation Refrigeration System. Taking Storage period(No.of days) on Y-Axis and type of Fruits stored on X-Axis. (The values of this graph taken from above analysis).



= Life of Fruit after keeping in the Food Preservation Refrigeration System.

= Normal life of Fruit..

Here Five different kinds of fruits have been taken for the experimental purpose .Where Ripeness Banana could be stored upto five days at 18℃ temperature.when banana keeps in food preservation refrigeration system . similarly ripeness grapes could be stored upto four days at 18℃

temperature, ripeness sapota , ripeness mango , ripeness strawberry could be stored upto three days at 18℃ temperature. successfully analyzed that Fruits can be stored more than normal time period .

1. Calculations for Heat Rejection:

With a cooling capacity of 50 watts and an efficiency of 75%.
The temperature inside the fridge is maintained at 18°C, while the ambient temperature outside is 28°C.
To calculate the heat rejection, first need to determine the amount of heat that is removed from the interior of the fridge. This can be calculated using the formula:
$Q = mc\Delta T$
where Q is the amount of heat removed, m is the mass of the air in the fridge, c is the specific heat capacity of air, and ΔT is the temperature difference between the inside and outside of the fridge.
Assuming the refrigerator is filled with air at a density of 1.2 kg/m³, the mass of air inside the refrigerator can be calculated as:
$m = \rho V = \rho AL$
where ρ is the density of air, A is the area of the refrigerator, and L is the height of the refrigerator.
Assuming a standard fridge size of 1.5 m² and a height of 1.5 meters, getting:
m = 1.2 x0.12 x 0.3 = 0.0432 kg = **43.2g**.
The specific heat capacity of air is approximately 1 kJ/kg.K, so:
Q = mcΔT =0.432 x 1 x (18 - 28) = **-4.32 kJ**
Note that the negative sign indicates that heat is being removed from the air inside the refrigerator
Next, calculate the amount of heat that is rejected by the refrigerator to the outside environment. This can be calculated using the formula:
$Q\_reject = Q / \varepsilon$
where ε is the efficiency of the refrigeration system. Assuming an efficiency of 75%, having:
Q_reject = Q / ε = -4.32 / 0.75 = **-5.76 kJ**
Again, the negative sign indicates that heat is being rejected to the outside environment.
Therefore, in this example, the refrigerator is rejecting **5.76kJ** of heat to the outside environment for every unit of time that it is running.

2. COOLING RATE OF FRUITS AT DIFFERENT HOURS:

Refrigeration temperature is set at 18°C and the initial temperature of the banana is 28°C. Estimate the rate of cooling using Newton's law of cooling, which states that the rate of cooling of an object is proportional to the temperature difference between the object and its surroundings.
The equation for Newton's law of cooling is:
$dT/dt = -k(T - Ts)$
where dT/dt is the rate of change of temperature of the object, T is the temperature of the object, Ts is the temperature of the surroundings, and k is a constant that depends on various factors such as the heat transfer coefficient, the surface area of the object, and the thermal conductivity of the object.
Assuming that k is a constant for a given banana and surroundings, simplify the equation to:
$dT/dt = -k(T - Ts)$
$dT/(T - Ts) = -k\, dt$
Integrating bothsides
$\ln(T - Ts) = -kt + C$
where C is a constant of integration. Rearranging the equation, gets:
$T - Ts = e^{(-kt+C)} = A\, e^{(-kt)}$
where $A = e^C$ is another constant.

Let's assume that at t=0 (initial time), the temperature of the banana is 28°C and at t=1 hour (1 hour later), the temperature of the banana is 23°C. Using these values, solve for k and A as follows:

$T - Ts = A e^{(-kt)}$

$28 - 18 = A e^{(0)} = A$

$23 - 18 = A e^{(-k*1)}$

$5 = A e^{(-k)}$

$(23 - 18)/(28 - 18) = e^{(-k*1)}$

$0.5 = e^{(-k)}$

k = -ln(0.5) = **0.693**

A = 10

Using the values of k and A, calculate the temperature of the banana at any time t as follows:

$\mathbf{T - Ts = A\, e^{(-kt)}}$

$T - 18 = 10\, e^{(-0.693t)}$

$\mathbf{T = 18 + 10\, e^{(-0.693t)}}$

By substituting any value of "t" at above equation, calculate the temperature of the banana as follows:

For Banana **t=0hrs**, then banana is cooling by

$T = 18 + 10e^{(-0.693t)}$ => $T = 18 + 10\, e^{(-0.693\times0)}$ => **T = 28℃.**

For Banana **t=1hrs,** then banana is cooling by

$T = 18 + 10e^{(-0.693t)}$ => $T = 18 + 10\, e^{(-0.693\times1)}$ => **T = 23.0007℃.**

For Banana **t=2hrs,** then banana is cooling by

T = 18+ 10 e(-0.693t) => $T = 18 + 10e^{(-0.693\times2)}$ => **T =20.5007℃**

For Banana **t=3hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times3)}$ => **T =19.2505℃**

For Banana **t=4hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times4)}$ => **T = 18.6253℃**

For Banana **t=5hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.3127℃**

For Banana **t=6hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.1563℃**

For Banana **t=7hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.0782℃**

For Banana **t=8hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.0391℃**

For Banana **t=9hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.0195℃**

For Banana **t=10hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.0097℃**

For Banana **t=11hrs,** then banana is cooling by

$T = 18 + 10e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.0048℃**

For Banana **t=12hrs,** then banana is cooling by

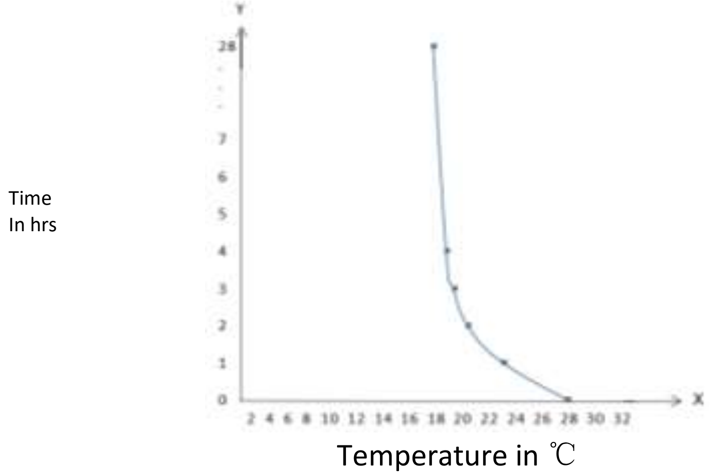
$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18.0024℃**

For Banana **t=28hrs,** then banana is cooling by

$T = 18 + 10\, e^{(-0.693t)}$ => $T = 18 + 10e^{(-0.693\times5)}$ => **T = 18℃**

Therefore, for **t =2hrs** Banana has cooled by **20.5007℃.** Similarly for all t values. At **t=28hrs** and above Banana is maximum cooled by 18℃ because our Food Preservation Refrigeration System maintain up to 18℃ only.

Graph between time and temperature for Banana Fruit Cooling. Taking time(hrs) on Y-Axis & Temperature on X - Axis. (The values of this graph taken from above calculations).



At 0hr, banana is at 28℃ When keeping the Banana in this system. At 1hr , banana has been cooled to 23℃. Similarly, the temperature of Banana to get 18.5℃ takes 5hrs. To get exactly 18℃ takes 28hrs. A graph is also plotted between the time and temperature of Banana Fruit.

Conclusion

From this project concluding that without the use of electricity and the Refrigerant It is possible to cool the system and fruits life increased.Five different kinds of fruits have been taken for the experimental purpose .Where Ripeness Banana could be stored upto five days at 18 ℃ temperature.when banana keeps in food preservation refrigeration system . similarly ripeness grapes could be stored upto four days at 18℃ temperature, ripeness sapota , ripeness mango , ripeness strawberry are could be stored upto three days at 18℃ temperature. successfully analyzed that Fruits can be stored more than normal time period .

The amount of heat rejection in this food preservation refrigeration system is 5.76KJ of heat to the outside environment. When the banana is keeping in this system, At 0hr, banana temperature is 28℃. After 1hr the banana temperature decreases to 23℃. The temperature of Banana to get 18.5℃ from 28℃ takes 5hrs. To get exactly 18℃ takes 28hrs. . A graph is also plotted between the time and temperature of Banana Fruit. By this experiment the life of fruits increased.in this experiment electricity not used by using solar panel the cooling cost of fruits degrease and it is useful to the small street vendors.

References

[1] M. M. Hussain, I. Dincer and S. M. Zubair "A feasibility study of using thermal energy storage in a conventional air-conditioning system" International Journal of Energy Research, Int. J. Energy Res. 2004; 28:955–967 (DOI: 10.1002/er.1006).
[2] Onoroh Francis, Chukuneke Jeremiah Lekwuwa, Itoje Harrison John, ―Performance Evaluation of a Thermoelectric Refrigerator‖ [IJEIT], Vol. 2, Issue 7, Jan 2013, PP 18-24.
[3] Fakeha Sehar, Saifur Rahman, Manisa Pipattanasomporn" Impacts of ice storage on electrical energy consumptions in office buildings" Energy and Buildings 51 (2012) 255–262, journal homepage: www.elsevier.com/locate/enbuild, Received 23 October 2011, Accepted 8 May 2012.
[4] Mehmet Azmi Aktacir "Experimental study of a multi-purpose PV-refrigerator system" International Journal of Physical Sciences Vol. 6(4), pp. 746-757, 18 February, 2011, DOI:10.5897/IJPS11.152, ISSN 1992-1950 ©2011 Academic Journals, Accepted 15 February, 2011.
[5] Kirti Singh, NishitaSakhare, SangitaJambhulkar, ―Compressor-less Refrigerator cum Oven‖ [IJRASET], Department of Mechanical Engineering, Vol. 3, Issue 4, April 2015, PP 1014-1019.

[6] ChakibAlaoui, ―Peltier Thermoelectric Modules Modeling and Evaluation‖, International Journal of Engineering (IJE), Volume (5): Issue (1): 2011, PP 114-121.
[7] Prof. VivekGandhewar, Miss. PritiBhadake, Mr. Mukesh P. Mangtani, ―Fabrication of Solar Operated Heating and Cooling System Using Thermoelectric Module‖, [IJETT], Vol. 4, Issue 4, April-2013, PP 586- 590.
[8] Sandip Kumar Singh and Arvind Kumar, ― Thermoelectric Solar Refrigerator‖, International Journal for Innovative Research in Science & Technology(IJIRST) Volume 1, Issue 9, February 2015 ISSN (online): 2349-6010, PP 167-170.
[9] Mr. Swapnil B. Patond, Miss. Priti G. Bhadake, Mr. Chetan B. Patond, ―Experimental Analysis of Solar Operated Thermo-Electric Heating and Cooling System‖, International Journal of Engineering Trends and Technology (IJETT) – Volume 20 Number 3 – Feb 2015, PP 125-130.
[10] P. Dasthagiri, H.Ranganna, G. Maruthi Prasad Yadav, ―Fabrication and Analysis of Refrigerator cum Chilled Water Dispenser‖, Advanced Engineering and Applied Sciences: An International Journal 2015; 5(1): PP 7-14.
[11] Simon Lineykin and Sam Ben-Yaakov,―Modeling and Analysis of Thermoelectric Modules‖ [ISRAEL] PP 2019-2023.
[12] MayankAwasthi and K.V Mali, ―Design and Development of Thermoelectric Refrigerator‖ [IJMERR], Vol. 1, October-2012, PP 389-399.
[13] Sanford A. Klein and Douglas T. Reindl "Solar Refrigeration" American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (www.ashrae.org). Reprinted by permission from ASHRAE Journal, (Vol. 47, No. 9, September 2005).
[14] S.M. Hasnain, S.H. Alawaji, A.M. Al-Ibrahim, M.S. Smiai "Prospects of cool thermal storage utilization in Saudi Arabia" Pergamon, Energy Conversion & Management 41 (2000) 1829-1839, www.elsevier.com/locate/enconman, Received 18 August 1999; Accepted 7 February 2000.
[15] Todd Otanicar, Robert A. Taylor, Patrick E. Phelan "Prospects for solar cooling – An economic and environmental assessment" Elsevier, Solar Energy 86 (2012) 1287– 1299, www.elsevier.com/locate/solener, Received 25 August 2011; received in revised form 16 November 2011; accepted 21 January 2012, Available online 17 February 2012.
[16] David MacPhee, Ibrahim Dincer, Asfaw Beyene "Numerical simulation and exergetic performance assessment of charging process in encapsulated ice thermal energy storage system" Elsevier, Energy 41 (2012) 491-498, Received 3 November 2011, Accepted 18 February 2012, Available online 27 March 2012, journal homepage: www.elsevier.com/locate/energy.
[17] B. Rismanchia, R. Saidur, H.H. Masjuki, T.M.I. Mahlia "Energetic, economic and environmental benefits of utilizing the ice thermal storage systems for office building applications" Elsevier, Energy and Buildings 50 (2012) 347–354, journal home page: www.elsevier.com/locate/enbuild, Received 29 September 2011, Accepted 2 April 2012.
[18] David MacPhee, Ibrahim Dincer "Performance assessment of some ice TES systems" Elsevier, International Journal of Thermal Sciences 48 (2009) 2288–2299, Received 20 September 2008, Accepted 7 March 2009, Available online 3 June 2009, journal homepage: www.elsevier.com/locate/ijts.

