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# Development of a Portable Hybrid Refrigeration System

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***Abstract*— In a hot country like Oman a huge amount of electricity is spent on refrigeration. Nowadays the economic development has resulted in lot of energy exploration, and the oil reservation becomes exhausted. In the present study, a portable hybrid solar refrigeration system which carries two refrigeration systems of 40 liters capacity has been designed, developed and analyzed.**

***Keywords—Hybrid; cooling potential; Absorption, Thermo electric, Refrigeration effect***

## I. INTRODUCTION

The human keeps searching for new sources of energy to meet his growing needs in the developed applications of life in which he lives. Some sources of energy are known of being exhausted, high cost of their utilization and negative impact of their use on the environment. The economic development has resulted in a lot of energy exploitation and the oil reservation becomes exhausted. It will run out within less than 50 years, causing the energy crisis. Many advanced countries in the world today take the lead in promoting research and development of renewable energies such as solar energy, wind energy, biomass energy etc. The importance of research and development on green energy has attracted much attention. Although their cost is high, continuous research and development will achieve the stable, easy to use and reasonably priced renewable energy in some day. Oman mostly depend on oil to meet the energy requirements. Oil is nonrenewable source of energy and the time has come to look for new sources. Solar energy will be a suitable choice in this region because of the huge amount available during the summer. There are remote places(deserts) in Oman where electricity is unavailable and the storage of medicine, vaccines or food materials become difficult. This research aims to develop a solar assisted portable hybrid refrigeration system which can store medicine, vaccines, food materials etc without the need of electricity. The study is to design and develop three solar refrigeration systems such as solar compression, Solar Absorption and Solar Thermoelectric to study and compare its thermal performance.

Experimental study of a multi-purpose Photovoltaic-refrigerator system was done by Mehmet Azmi Aktacir [1] in 2011. In this study, a PV-powered multi-purpose refrigerator system has been established to investigate experimentally its daily and seasonal operating performance. In this study the parameters affecting the system capacity and performance were determined experimentally. A hybrid fridge using Ammonia absorption was developed by Njoroge Alex Kanyongain, University of Nairobi [2] in 2011 .The project has the objective to solve refrigeration challenges. It takes advantage of the abundant solar energy in hot climate running primarily on heat from the sun and using Ammonia as the refrigerant.

A Solar Powered Absorption Refrigerator was developed by Ramsey Brown, Kati Nava, Sidney Palmer, and Joseph Tudel [3] in Cahtormic Academy in 2011. Ammonia - water vapour absorption system was used to generate the cooling and the electricity to run the system from two 12 V batteries. A 135 Watt photovoltaic panel was used and they obtained a minimum refrigerator inside temp of 30°F and coil temperature reached was -17°F. This entire system was mounted on a wheeled cart for easy mobility and portability.

Experimental study on combined solar assisted ejector Absorption refrigeration system was done by J.M Abdulateef ,Nurul Muzi Murad,M.A Alghoul,A.Zaharim and K.Sopian [4] in 2011. In this paper, results related to both conventional and combined systems driven by solar energy using Ammonia-water are presented and the effects of operating temperatures are investigated. The results show that, the combined cycle provides potentially high COP than that of the conventional absorption machine. The maximum increase in COP is about 50% higher than the basic cycle. It was seen that if higher cooling capacity and also lower evaporator temperature are desired from the system, the generator temperature should be increased considerably.

## II. METHODOLOGY

### *A. Experimental Set-up*

A portable refrigeration system to accommodate absorption and a compression system of capacity of 40 liters each has been designed developed and tested. The refrigeration cabin was designed with a size (1000×650×700) $mm^3$ to combine two systems together and portable. Each system has a cooling cabin of size (320×270×450) $mm^3$. The internal cooling cabin is made by Aluminum sheet. The external box is made to resist the heat in leak from surrounding and to reject the moisture and water coming from the foam. It is then covered by a fiber sheet. The foam insulation is filled between the inner and outer boxes with 2 cm gap. The doors with foam insulation are made by the above method. The solar panel is mounted on a wheeled cart which carry the batteries and refrigeration unit. The panel would then rotate to the desired angle to maximize solar intensity. Solid work software is used to design the various components of the portable hybrid refrigeration system. While designing attention is being given for the system to be portable and to accommodate at least two systems with a capacity of 40 liters. Depending on the solar radiation the solar panel could be tilted with this motorized arm. The developed system is shown in fig.1

Fig.1 Experimental Set-up

## III. PERFORMANCE STUDY OF SOLAR REFRIGERATION SYSTEMS

For each system the performance study was conducted at 12:30 pm. The study was conducted for 3 hours continuously. After every hour of operation, the orientation of the Solar panel was adjusted to receive the maximum amount of solar radiation. This is done with the help of a motorized arm connected at the solar frame. The performance test was to place 500 ml room temperature water as a cooling load inside the solar refrigerator. The experiment was conducted at 12:30 pm under the sunlight.

## IV. RESULTS AND DISCUSSION

### A. Solar Vapour Compression system

Initial ambient temperature was 32.07°C and the cold side temperature was 27.78°C. The system was allowed to run with a cooling load of 500 ml water. The variation of cold side temperature and the cooling load temperature (water) of solar vapour compression system is shown in Fig.2. After running for 20 minutes, the cold side temperature dropped to -9.24°C and then after 100 minutes of operation, the cold side temperature dropped to -16.5°C. The cold side temperature slowly dropped to a minimum temperature of -17.4°C after 3 hours of continuous operation.

The cooling load (water) temperature of solar vapour compression dropped to 19.99°C after 20 minutes and then dropped to 0.99°C after 100 minutes of operation and would be even lower if the system was still running on. The average ambient temperature was noted to be 33.12°C.

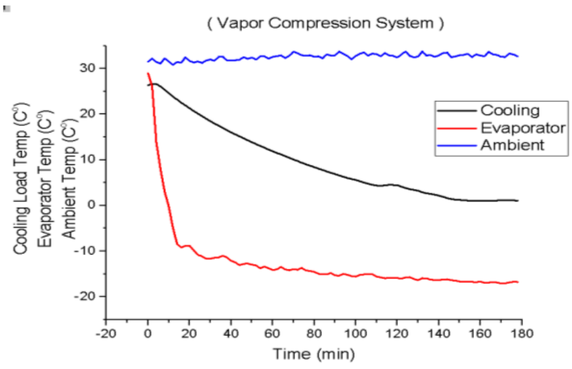


Fig.2. Temperature Profile of Solar Vapor compression system

### B. Solar Vapor absorption system

The loaded test was to place the 500 ml room temperature water inside a vapor absorption refrigerator. The experiment was conducted at 12:30 pm under sunlight. Initial ambient temperature was 30.64°C and the cold side temperature was 26.63°C. The system was run with a cooling load of 500 ml water. The trend of cold side temperature and the cooling load temperature (water) of solar vapour absorption systemis shown in Fig.3. After running for 20 minutes, the cold side temperature dropped to 25.23°C. After 100 minutes of operation, the cold side temperature dropped to 4.18°C. The cold side temperature slowly dropped to a minimum temperature of 1.66°C after 3 hours of continuous operation.

The cooling load (water) temperature of solar vapour absorption dropped to 24.84°C after 20 minutes and then dropped to 20.74°C after 100 minutes and would be even lower if the system was still running on. The water temperature dropped very slowly from the beginning at 24.53°C to a minimum of 16.17°C. The average ambient temperature was noted to be 31.21°C. For every hour of operation, the orientation of the Solar panel was adjusted to receive the maximum amount of solar radiation

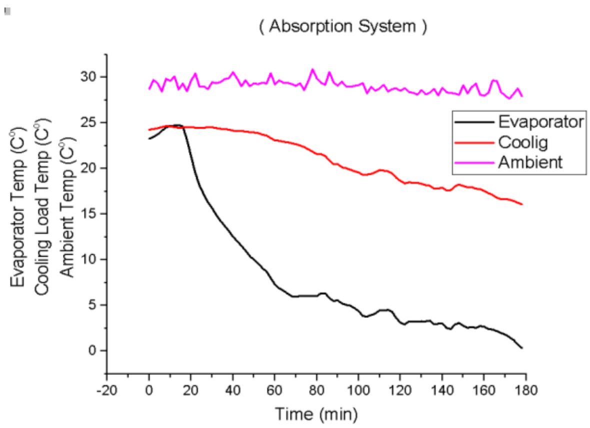


Fig.3. Temperature Profile of Solar Vapour Absorption System

### *C. Solar thermo electric System*

Initial ambient temperature at the beginning of the study and the cold side temperature were 36.79°C and 27.76°C respectively. The system was allowed to run with a cooling load of 500 ml water. The variation of cold side temperature and the cooling load temperature (water) of solar thermoelectric system is shown in Fig.4.

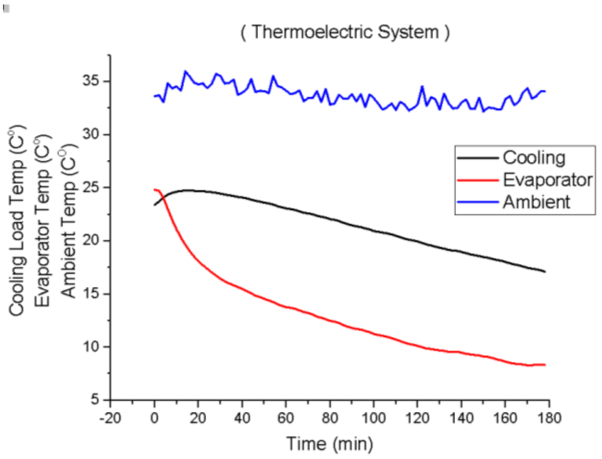


Fig.4. Temperature Profile of Solar Thermo electric system

After running for 20 minutes, the cold side temperature of solar thermoelectric dropped to 20.78°C. After 100 minutes of operation, the cold side temperature dropped to 22.3°C. The cold side temperature slowly dropped to a minimum temperature of 9.85°C after 3 hours of operation. The cooling load (water) temperature dropped to 24.55°C after 20 minutes and then dropped to 22.3°C after 100 minutes and would be even lower if the system was still running on. The water temperature dropped very slowly from the beginning at 23.7°C to a minimum of 19.08°C. The average ambient temperature was noted to be 35.69°C.

## V. CONCLUSIONS

A portable hybrid refrigeration system has been designed, developed and tested. The comparative study of the solar vapour Compression, solar absorption and solar thermoelectric have been done. The study shows that the thermal performance of solar vapor compression system is much higher than other two solar refrigeration systems. It was discovered that for the first 26 minutes of operation solar thermoelectric system has higher performance than absorption system. After 26 minutes of operation, performance of Absorption system significantly increases in comparison with solar Thermo electric system and the lowest temperature in evaporator and cooling load was achieved. The cooling potential of Solar Absorption system was found to be better than Solar Thermoelectric system in terms of minimum temperature achieved.

## REFERENCES

[1] AktacirM.A, Experimental Study of a multi-purpose PV-refrigerator system, International Journal of Physical Sciences Vol. 6(4), pp. 746-757, 18 February, 2011.

[2] Kanyonga.N.A, The Hybrid Fridge using ammonia, Department mechanical and manufacturing engineering,pp1-21, University of Nairobi, 2011.

[3] Brown.R, Nava.K, Plamer.S and Tudela.J, Solar Powered Absorption Refrigerator, Vol 34, pp 205-247, California Maritime Academy, 2011.

[4] Abulateef.J.M, Murad.N.M,Alghoul.M.A, Zaharim.AandSopian.K, Experimental Study on combined solar assisted ejector absorption refrigeration system, University Kebangsaan Malaysia, Malaysia.

[5] Majeed.U, Hussin.M.A, Studying the performance of refrigeration unites powered by solar, University of Nahrain, Iraq, Iraqi Journal of Chemical and Petroleum EngineeringVol.14 No.1 (March 2013) 39-46, www.iasj.net.

[6] R.Saiduar, H.H Masjuki.M, Hasanuzzaman, T.M.I, Mahlia C.Y, Tan.J.K. and P.H.Yoom , Performance investigation of solar powered thermoelectric refrigerator ,Department of mechanical engineering , University of Malaya, 2008.

[7] Adavbiele.A.S, Integrated Flat Plate Solar Thermoelectric System from Department of mechanical engineering, Ambrose Alli University, 2012.

[8] Rawat.M.K, Sen.P.K, Chattopadhyay.H and Neogi.S, Developmental and Experimental study of solar powered thermoelectric refrigerator system from mechanical engineering Department, Jadavpur University Kolkata, west Bengal, India, Aug2013.

[9] Borkar.D.S, Prayagi.S.V and Gotmar.J, Performance of Photovoltaic Solar Panel Using Thermoelectric Cooling from International Journal of Engineering Research , Volume No.3, Issue No.9, pp : 536-539, 01 Sept 2014.

[10] Gupta.S.K, Enhancing the performance of solar refrigeration system., Maharashtra of Institute of Technology, Vol 4,pp2666-2669,University of Pune ,India, International Journal of Science and Research, Volume 3 Issue 6, June 2014, www.ijsr.net.

[11] Bansal P.K.and Martin A, Comparative study of vapour compression ,thermoelectric and absorption refrigerator, International journal of Energy Vol 24(2), 93-107, (2000).