STUDY OF SOLAR POWERED VAPOUR ABSORPTION AIR CONDITIONING SYSTEM

Md. Irshad Alam Ansari[1], Sohail Bux[2]

1. M. Tech Scholar, AGNOS College of Technology, RKDF University Bhopal
2. Associate Professor, AGNOS College of Technology, RKDF University Bhopal

Abstract

The twenty first century is hurriedly becoming the perfect energy hurricane, modern society is faced with volatile energy prices and growing environmental concerns as well as energy supply and security issues. Fossil fuels such as coal, petroleum and natural gas have been the main energy resources for everything vital for human society. The burning of fossil fuels has caused and is causing damage to the environment of earth. By 2050 the demand for energy could double or even triple as the global population grows and developing countries expand their economies. Energy is the spine of the technology and fiscal development. Solar energy provides rich source of renewable energy. An air conditioning system utilizing solar energy would generally be more efficient cost wise, if it was used to provide both heating and cooling requirements in the building it serves. Many researchers have studied the solar absorption system to make it economical. This air conditioning system can be used in those areas where electricity cost is very high or non electrified areas. This review paper focused on design and construction of solar powered absorption air conditioning system which consists of the photovoltaic panels, solar charger, inverter and batteries.

Keyword: - Solar Energy, Photovoltaic Module, Air Conditioning System, Global Warming, Climatic Condition

Introduction

The demand of air conditioning is increasing due to the effect of climate change and global warming. The earth surface receives a daily solar dose of 10E+8 kW-hr, which is equivalent to 500000 billion oil barrels that is one thousand times any oil reserve known to man. Many researches are being conducted in those countries where more availability of solar energy likes India, Saudi Arabia etc. On hot summer days the electricity grid increasingly faces the danger of overload due to air conditioning use, which would cause essential service disruption. Solar air conditioning is one of the few solutions provided to overcome the summer highly required and addressed peak loading and does so with reduced environmental impact. Solar energy is generally reasonable and has capability to meet household demand over the year. The main purpose of using solar is to reduce the emissions of CO_2 and harmful gases

that are responsible for global warming and ozone layer depletion.

Solar power absorption air conditioning system has some attractive features such as its system requiring minimum maintenance and operational cost and it does not have negative effects on the environment. Another important feature of solar energy is its ability to satisfy rural areas where conventional energy system might be not suitable or uneconomical. Therefore this work is focuses in the design and construction of solar powered air conditioning system integrated with photovoltaic system. In this system photovoltaic module is used to convert sunlight into electricity. Solar photovoltaic system is very reliable and clean source of electricity that suit a wide range of application such as residential, industrial and agriculture etc.

Solar powered air conditioning system was designed, installed and operated in Singapore (Bong, 1987). Feasibility of utilising solar power for comfort cooling in Hong Kong has been studied; a solar powered absorption air conditioning system was designed and successfully constructed on the campus of the University of Hong Kong (Yeung, 1992). The actual Solar powered system can be shown fig below

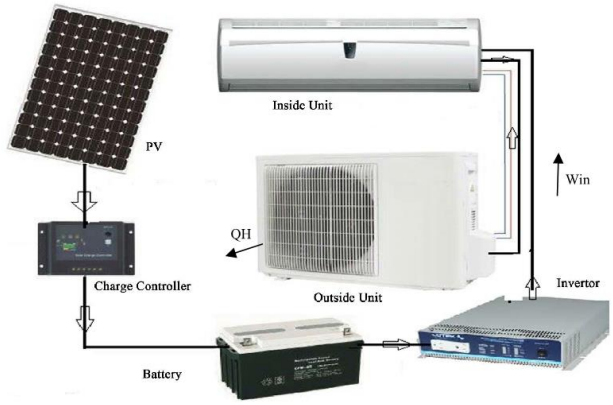

Fig: 1 Actual System Cycle

Literature Survey

Nowadays our society is facing many problems because our conventional energy is limited, but in coming years the demand of energy will be double or triple around 2050. Therefore more fossil fuels are required to produce electricity. Hence the need of such energy which produces less or minimum harmful gases and will be environment friendly to cool indoor areas of the buildings.

Khaled S. Al Qadah et al. [1] Studied the design and performance of the system in Al Madinah Al Munawwarah to cool the environment by solar energy. His work focused on design, construction and testing the performance of solar powered air conditioning system integrated with photovoltaic system and applying it under Al Madinah and Al Munawwarah climatic circumstances. It was designed by two different one of them is preferred upon the other because of the suitable range of voltage and simple connection. The COP for the system was found to be with a good agreement with conventional system. Solar air conditioning system can be responsible alternative to conventional air conditioning system. He found there are numerous features that must be considered to know either on photovoltaic system or on the air conditioning system such as electrical equivalent, characteristic curve and factors affects the output of photovoltaic cells. Solar energy as a power source can reduce high energy demand and increase the use of responsible energy, while providing energy savings to the end user.

V.K. Bajpai et al. [2] Designed and studied vapour absorption refrigeration system, which is environment friendly. The system used by the V.K. Bajpai was having unit capacity and R-717 used as a refrigerant. Water is used as absorber or the working medium; he used the flat plate collectors for heating the strong solution to vaporise and separate ammonia vapour from the water. He also explained the performance of the system module and overall system for different working conditions

K Karthik et al. [3] It has designed the model of vapour absorption system having 0.0168TR Capacity and tested it for various operating conditions and constraint and after study and calculations he proved that the solar powered vapour absorption system is feasible.

Tarik A. Shaikh, Yogesh J. Morabiya et al. [4] In study of the solar operated vapour absorption system and with the help of their study and investigation they also confirmed that the vapour absorption system is also a feasible way to finish work done the mathematical modelling and use of CFC's and HFC's. They also use Li-Br model of vapour absorption system and determined the COP of the system.

Satish Raghuwanshi, Govind Maheshwari et al.[5] It has studied the relation characteristic and performance of the single stage ammonia water vapour absorption system and confirm that the vapour absorption refrigeration by using solar power is feasible substitute for the conventional refrigeration system which are using the conventional power source.

K.R. Ullah et al. [6] Now a day more countries are endeavouring to exploit renewable energy than ever before. Pollution, higher costs and limited resources are the main obstacles to the pervasive use of fossil fuels. Therefore, renewable energy sources, such as solar energy, have been of considerable interest because of their promising advantages. Because of the year-round availability of sunshine, solar energy can be easily captured all over the world. Though the solar photovoltaic system can provide electricity as well as refrigeration, solar thermal refrigeration is much more efficient. Solar thermal cooling technologies are being used all over the world for industrial and home cooling purposes. These cooling systems are more applicable in remote areas or islands where conventional cooling is difficult and solar energy is always available. This study also summarizes the different working fluids of solar absorption cooling systems and adsorption cooling systems, providing various results with their advantages and limitations. Though the coefficient of performance of absorption cooling systems is better than that of adsorption systems, the higher temperature issues can be easily handled with solar adsorption systems. Moreover, solar hybrid cooling systems can provide higher capacity and better coefficients of performance by eliminating some of the problems encountered with individual working pairs.

Ravi Gungulothu et. al. [7] It has basically focused on environment pollution, emission of CO_2 gases due to which global warming takes place and demand of electricity increases day by day. In the next coming year around 2050, the

demand of electricity and it cost will be very high. In vapour compression air conditioning system also have major effect on stratospheric ozone depletion. If solar powered air conditioning system is used instead of vapour compression air conditioning system then the load of electricity may be reduced.

A. Vaidyanathan et. al. [8] It has presented in his studies that in India abundant solar radiation receives per year nearly more than 5000 trillion kWh/year. These energies are sufficient for annual energy requirement. By the use of solar energy we can reduce the burden of conventional fuels. In commercial as well as residential buildings require of excess electricity for air conditioning. In various devices like solar home appliances, solar street lights, solar pumps etc are used solar energy with the help of photovoltaic technologies.

Edlas Khor Jiunn Hao et. al. [9] It has comparison between conventional air conditioning system and solar air conditioning system and concluded that a need of high electricity for fulfilment of demand. Hence they focus on solar energy and made a solar air conditioning system in the campus of Limk kwing University and made calculation in saving of electricity and found finally outcomes is towards saving of electricity cost and also this solar system is environment friendly.

Working Principle of Air Conditioning System

The proposed concept of the system consists of air conditioner and PV system is indicated in block diagram shown in Figure: 2. In order to determine the characteristics and properties of all the components used, each component must be taken as a single unit. The complete system must be able to operate in stable condition, and if possible achieving the efficiency as conventional air conditioning system. For example, as for the cooling purpose, performance of the DC air conditioning should be the same as normal AC air conditioner.

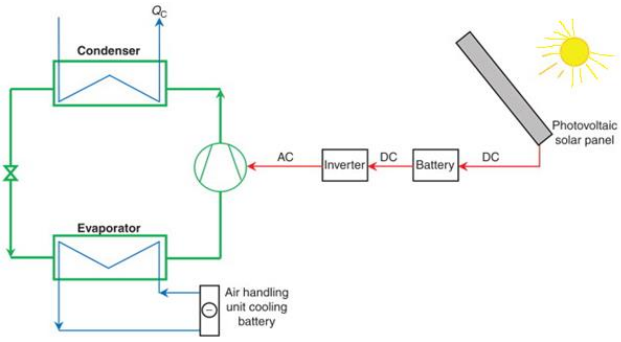

Fig: 2- Block Diagram of Solar Air Conditioning System

Air Conditioning System either for a building or a vehicle, the air conditioner mainly consists of five key components which are compressor, refrigerant, expansion device, evaporator and condenser. The compressor is electrically operated can be described as the heart of air conditioning system as it pump refrigerant throughout the system. The main function of a compressor is to compress refrigerant vapour to a high pressure, making it hot for the circulation process of the refrigerant. Refrigerant is a material that performs as cooling agent by absorbing heat into the system and will circulating inside the circuit of the air conditioning system. Located in between of the condenser and evaporator, the expansion device allows a controlled amount of the liquid refrigerant to flow through into the low-pressure section of the process. The expansion device is used in air conditioning system in vehicle. For

the circulation process of the refrigerant, evaporator use the liquid state refrigerant to absorbs the heat from the cooling space into the system. The evaporator is located inside the indoor unit installed in the cooling area. At condenser, as the temperature of the refrigerant is low, the heat from the system that the evaporator absorbs is being removed. The condenser is situated inside outdoor unit with the compressor. Photovoltaic is consists of two words; photo and voltaic, photo is used for light and voltaic for electricity. Hence photovoltaic system converts the energy of sunlight directly into electricity. The conversion from the sunlight into electricity is occurred because of the photovoltaic effect. The term "solar cell" is reserved for devices intended specifically to capture energy from sunlight while the term "photovoltaic cell" is used when the light source is unspecified. A whole photovoltaic system comprises two subsystems. First subsystem is the photovoltaic modules that convert sunlight into electricity. In between the first subsystem and air conditioner, there will be second subsystem which is a set of devices and structures that enables the photovoltaic electricity to be properly applied to the load. This third subsystem is known as "balance of system". PV module is categorized according to their rated power output in Watts. This rating is the amount of power the solar panel would be expected to produce in 1 peak sun hour (PSHs). Different geographical locations receive different quantities of average peak sun hours per day. The peak sun hour is essential in order to know the number of PV modules to be installed. Before doing so, the power that can be assumed generated by the PV modules must be determined based on solar irradiance of the location. The BOS in this system consists of inverter, charge controller and battery. The function of charger is to control the voltage and current coming from the solar panel going to the battery. The battery is the key components in the systems as it act as energy back-up for the renewable energy systems. Also its functions as storage devices for storing PV generated electricity during cloudy days and at night. In order to apply this system in AC load, the inverter is needed to convert the DC electricity generated by the PV panel into AC. The AC load is a common type of load and easily available with cheaper in price. The battery storage must have enough capacity to handle the energy demands by the system especially during periods of very low solar radiation, likes rainy season, cloudy climate or at night

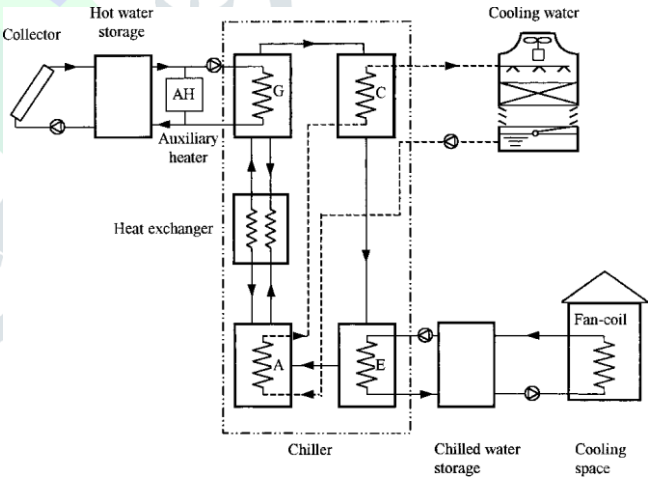

Fig: 3- Basic operation of Air Conditioning system

The solar energy is received by the PV module and transform into electrical energy and is then being regulated by charge controller either by supplies it directly into the load or charges the batteries. When the electrical energy coming from the photovoltaic module is in DC, inverter

will convert it into AC as the compressor needs AC to operate. The common type of air conditioning is technically referred to as direct expansion, mechanical, vapour-compression refrigeration system. The objective with air conditioning is to capture heat in the cooling space and throw it outside. The process of the system starts when the cold, low pressure refrigerant which is in liquid state, flows across the evaporator coil inside the cooling space to absorb heat. From the evaporator cold liquid refrigerant comes out as a low pressure gas and the cool, low pressure gas is taken outside and compressed by the compressor to become a hot, high pressure gas. After that the hot gas is passed through the condenser coil and gives off some of its heat as outdoor air is blown across the coil. This cause the hot gas to condense back to into a hot liquid. The hot liquid is carried back to the evaporator by passing through the expansion device which decreases the temperature and pressure of the liquid.

Application of Solar Energy in Cooling

In order to evaluate the potential of solar energy for the different solar cooling systems, a classification has been made by the scientists Best and Orgeta (1998). It is based on the two main concepts – solar thermal technologies for the conversion of solar heat into hot water, and the solar cooling technologies or the cold production.

The solar thermal technologies are:

• Flat plate collectors

• Parabolic collectors

• Evacuated tube collectors

• Stationary, non imaging concentrating collectors

• Linear focusing concentrators

• Solar pond

• Photovoltaic

Fig (a) Flat pate collector

Fig (b) Evacuated tube collector

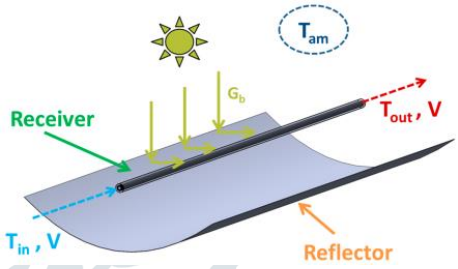

Fig (c) Parabolic collector

The cooling technologies are generally classified into two main groups depending on the energy supply

1. **Thermal/work driven system**

• Absorption refrigeration cycle

• Adsorption refrigeration cycle

• Chemical reaction refrigeration cycle

• Desiccant cooling cycle

• Ejector refrigeration cycle

2**. Electricity (Photovoltaic) driven system**

• Vapour compression refrigeration cycle

• Thermo-electric refrigeration cycle

• Stirling refrigeration cycle

Different possible "paths" from solar energy to the "cooling services" are shown in Figure 4.

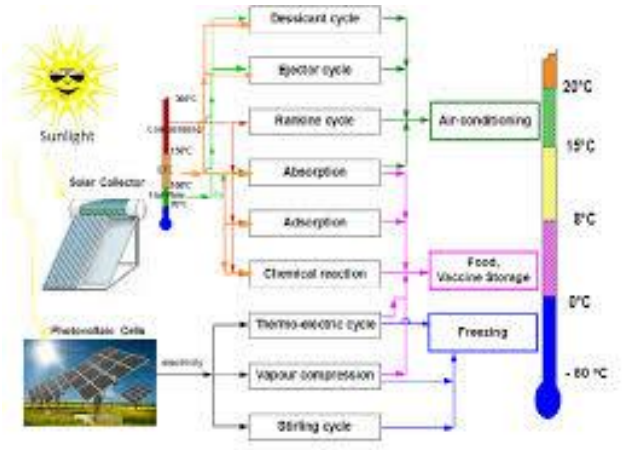

Fig: 4- Different Paths from Solar Energy to the Cooling Services

Conclusion

This paper concludes that the system design needs to consider both air conditioner and PV system in order to achieve the space cooling. There are several characteristics that are needed to know either on the PV system or air conditioning system. Electrical equivalent, IV characteristic curve and factors affect the output of PV cell is an important characteristic in photovoltaic. As for the air conditioning, cooling capacity must be determined first as it will give a rough idea on how to design and construct the system with enough electrical energy supplied to it. With considering of these several factors, it will help to improve the stability and efficiency of the system for greener solutions to the world's energy needs.

Future Scope

A lot of future scope in the solar powered air conditioning system design and construction to improve the overall system. There are various factors which affect the solar energy availability on solar collector's surface like types of collector used, orientation of collector surface their tilt etc. A parametric study is required to improve the overall system performance. When the solar plate gets more heated then the efficiency of plate is decreased. Therefore, if a cooling coil or a fan is attached to the bottom of solar plate then at high temperature the efficiency of solar plate can be improved.

References

[1] Sameh Alsaqoor, Khaled S. AlQdah *Performance of a Refrigeration Absorption Cycle Driven by Different Power Sources*

[2] V. K. Bajpai Design *of Solar Powered Vapour Absorption System Proceedings of the World Congress on Engineering* 2012 Vol III WCE 2012, July 4 - 6, 2012, London, U.K.

[3] K Karthik, "*Design, Fabrication and Analysis of Solar Vapour Absorption Refrigeration System"* International Journal of Emerging Technology and Advanced Engineering, Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 9, September 2014).

[4] Tarik Shaikh, Prof. Yogesh J. Morabiya, "*Review of Solar Absorption Refrigeration System Using Libr-Water and Simulate The performance Of the System"* International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974.

[5] Satish Raghuvanshi, Govind Maheshwari *Analysis of Ammonia –Water (NH3-H2O) Vapour Absorption Refrigeration System based on First Law of Thermodynamics* International

Journal of Scientific & Engineering Research Volume 2, Issue 8, August-2011 1ISSN 2229-5518

[6] K. R. Ullah R. Saidura,b , H.W. Ping a , R.K. Akikur a , N.H. Shuvo *A review of solar thermal refrigeration and cooling methods Renewable and Sustainable Energy Reviews* 24 (2013) 499–513

[7] Ravi Gugulothu, Naga Sarada Somanchi, Hima Bindu Banoth & Kishan Banothu," *A Review on Solar Powered Air Conditioning System*", Science Direct, Procedia Earth and Planetary Science 11 (2015) 361-367.

[8] A. Vaidyanathan, "White *paper on Solar Thermal Technologies"* Cleantech Consultants, www.cleantechconsultants.in, 2012.

[9] Edlas Khor Jiunn Hao and Ali Ghaffarian Hoseini," *Solar vs. Conventional Air-Conditioning Systems: Review of LIMKOKWING University Campus, Cyberjaya, Malaysia*", Journal of Creative Sustainable Architecture & Built Environment, Vol.2, December,2012.

[10] Sayigh, A.A.M. (1981) *Solar Air Conditioning in a Hot Arid Climate*. Proceeding of the Second Miami International Conference, Miami Beach, 10-13 December 1979, 761-773

[11] S. Shaari, A.M. Omar, A.H. Haris, S.I. Sulaiman and K.S. Muhammad, *Solar Photovoltaic Power Design and Installation of Stand-Alone Systems*, Pusat Tenaga Malaysia;2009,pp.46-52, 119-129.

[12] Bong, T.Y, Ng, K.C. and Tay, A.O. (1987) *Performance Study of a Solar-Powered Air Conditioning System*, Solar Energy, 39, 173-182.

[13] Mattarolo, L. (1982) *Solar Powered Air Conditioning System:* A General Survey, International Journal of Refrigeration, 5, 371-379.

[14] Tsilingiris, P.T. (1993) *Theoretical Modelling of a Solar Air Conditioning System for Domestic Applications.* Energy Conversion and Management, 34, 523-531.

[15] Choudhury B, Chatterjee PK, Srkar JP. *Review Paper on Solar Powered Air Conditioning through Absorption route.* Renewable and Sustainable Energy Reviews 2010, 14(8):2189-95.