International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 9 ǁ September 2022 ǁ PP. 159-165

A Term Paper Review Report On a Solar Cooling System

P.SIVA GOPI [1], SULEMAN KHAN[2], P.ROHITH[3], K.N.V HEMANTH[4], M.NITHIN KALYAN[5], CH. SRILATHA[6]

*[*12345]Student, Dept. of Mechanical Engineering, NRI Institute of Technology, Agiripalli, Andhra Pradesh, India,*
[6] Associate Professor, Dept. of Mechanical Engineering, NRI Institute of Technology, Agiripalli, Andhra Pradesh, India.
Corresponding Author: P.SIVA GOPI

Abstract –
The increase in demand of air-conditioning has increased the electricity consumption of the building. The conventional vapor compression system is main cause of high electricity consumption. The residential building has large percentage of this consumption. The high energy consumption and limited sources, leads the world to energy shortage. The solar air-conditioning system is a best alternative of conventional air-conditioning system. There are various types of solar cooling technologies namely solar photovoltaic, desiccant cooling adsorption and absorption cooling system. Solar absorption cooling system is developed and simulated in TRNSYS with three types of solar collectors namely E.T.C, F.P.C and P.T.C. The parameter storage tank volumes and flow rate are used to study the performance of solar cooling system.

Keywords: *Solar cooling system, solar panels, solar energy, collector system, heat.*

Date of Submission: 26-08-2022 Date of acceptance: 10-09-2022

I. INTRODUCTION

From earlier the history of the human race, major advances in civilization have been measured by the increase in the rate of energy consumption. Today, energy consumption appears to be related to the life standards of the people and the degree of industrialization of the countries. However, the world today faces unfavorable condition of environmental pollution on a scale that has not been faced earlier in human history because of huge revolution in human use of fossil fuel in all activities, it is also Global warning for further temperature increase by 1.5-4.5 K up to 2110. In order to avoid these unfavorable conditions, we need to reduce the harmful emission resulting from burning fossil fuel as a source of energy. This can be achieved either by increasing energy conversion efficiency of the fossil fuel based system or using renewable source of green energy. Among these sources, solar energy is the most important, effective and attractive source; because of the solar energy universal abundance and unlimited nature unlike many other renewable energy sources. The attractive characteristic of solar energy is continuous source being unending even it is intermittent source during the day and night. In addition, solar energy does not cause air pollution or affect the earth’s atmosphere as fossil fuel. Solar energy is easy to collect unlike the extraction of fossil fuel. In the field of solar thermal system, solar cooling has huge potential, because the cooling demands reach its peak coincides with peak solar energy availability.

1.1.1 Solar Cooling system Classification

Solar Cooling system can be classified in three main categories: solar electrical, thermal and combined power/cooling cycles as shown in Figure 1.

1.1.2 Solar Cooling System and Application Temperature Ranges

The solar cooling system can be divided into three major components; solar energy collecting element, refrigeration cycles, and the application at different temperature ranges. The perfect cycle for each application mainly can be selected on cooling demand and required temperature ranges. Figure 2 shows different solar cooling systems that could generate refrigeration effect at different temperature ranges. Some applications are require for different range of cooling which cannot be achieved by any single refrigeration cycle. The Multi-effect system is the best way to getting a different magnitude of refrigeration effect and temperature ranges by using solar energy that helps in decreasing problems affecting the environment.

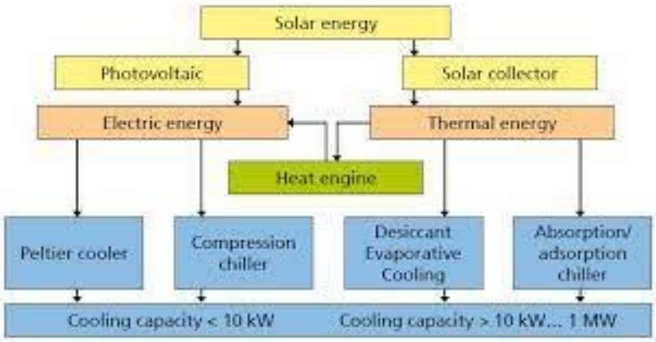

Figure1: Solar Cooling Technology.

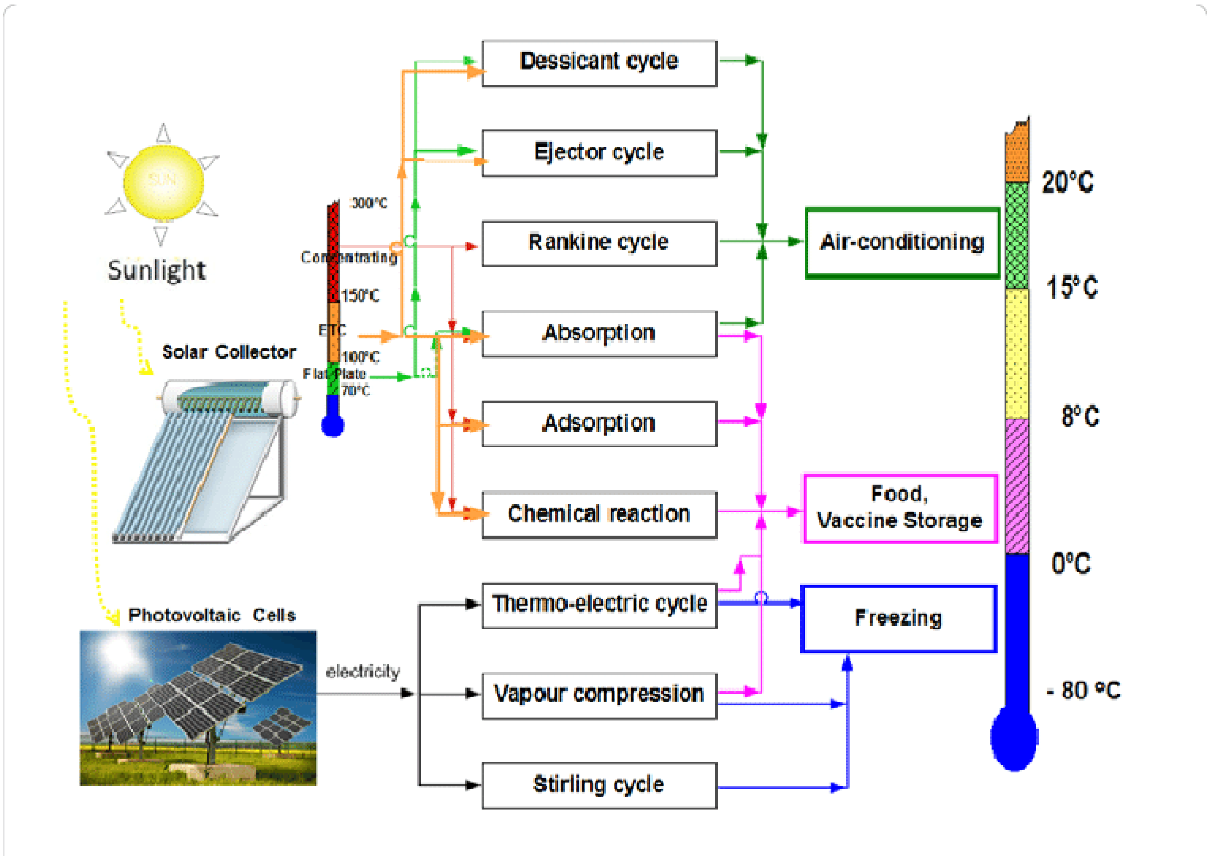

Figure2: Solar Cooling System and Application Temperature Ranges

1.2 Solar Electrical Cooling System

The solar electrical cooling system consists of photovoltaic panel and electrical refrigeration device. Photovoltaic cells convert light energy into electricity energy by photoelectric effect. Many of solar electrical refrigeration system are create for independent operation. The PV cells made of semiconductor materials, single crystalline thin films, poly-crystalline and silicon-wafers represent the solar panel materials, and silicon is main component of PV cell in the market. The efficiency of polycrystalline thin films is greater than that of silicon wafer, the efficiency of polycrystalline thin films in range of 10 to 16%, single crystalline thin file efficiency can reach 16 to 20% by using multi-junction cell structure, while as silicon wafer performance is low and its cost are high compare the thin film technologies. The produced power by solar photovoltaic cells is supplied either to the thermo-electrical system, Stirling cycle or vapor compression systems.

1.3 Solar Powered Vapor Compression Cooling System

PV panel transform solar radiation to DC power which is supplied to a conventional vapor compression system. The Coefficient of performance of the system depends on the efficiency of the PV panel. The solar radiation is intermittent source, and the solar radiation will not be available all times therefore an alternative source of power to run the system is required when the solar radiation becomes low or unavailable (Figure 3).

The cost of electricity supplied from photovoltaic is equal to or cheaper than grid power, is easily achieved in sunny areas and high costs for grid electricity such as in United States and Japan [Going for grid parity 2005 article]. Klein and Reindl investigated the electrical characteristics that produced from Photovoltaic cells and compare it with required characteristics of compressor motor. The most important characteristic is the voltage that should be close to voltage producing the maximum power in order to run the system at highest efficiency. This can be done by many ways to track the highest power then select electric motor with current and voltage producing maximum power of the system.

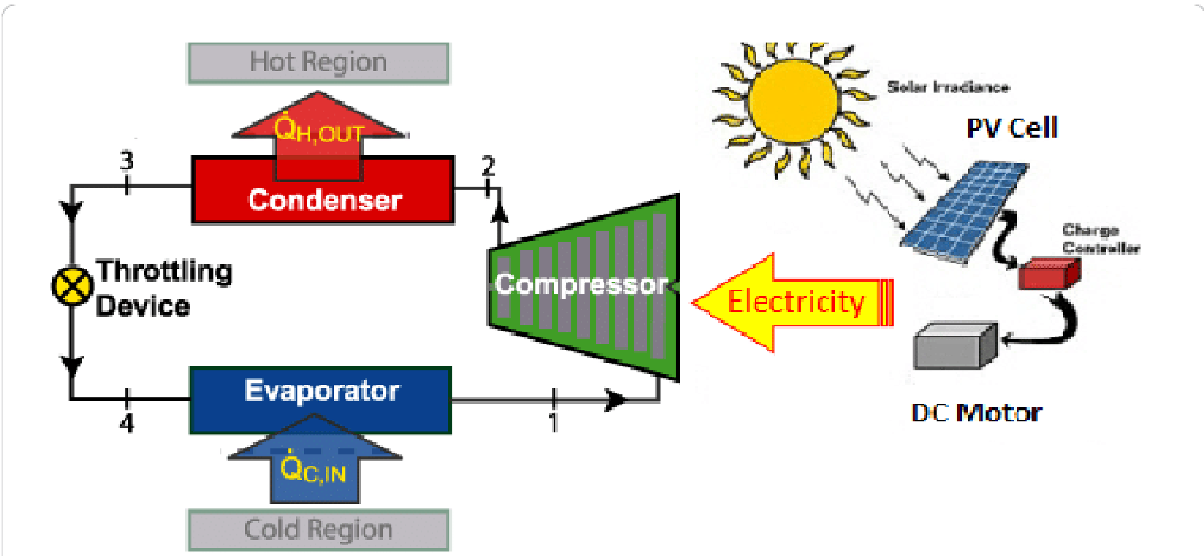

Figure3: Solar Powered Vapor Compression cycle

1.3 Open Sorption Cycle Solar Cooling

It represents desiccant systems that are used in air conditioning applications for humidification or dehumidification basically changes moisture from one air stream to another one. These cycles can be used as pre-cooling of other system and can be used to provide cooling for specific application with special requirement (Figure 4). The main operation concept of open sorption cycle is to absorb and release the moisture in three processes as follow: Description of Open Sorption Cycle Solar Cooling.

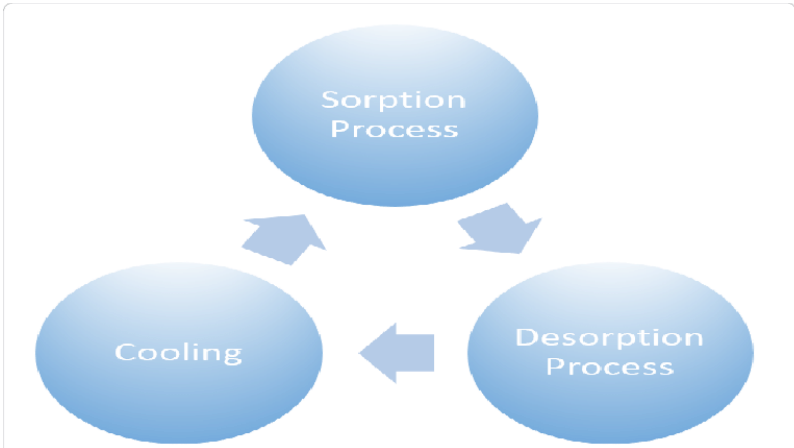

Figure4: Process of Moisture Transfer by Desiccant.

1.4 Liquid Desiccant System

The system consists of a conditions and regenerator, the principle operation of the system as follow: The liquid desiccant is pumped and passes through nozzle that will spray the desiccant in the air to absorb the moisture from air due to difference in surface vapor pressure of the desiccant and air(Figure 5). The liquid desiccant falls to the basin of conditioner and spray back in air, the desiccant temperature and pressure has increased The water content increased due to absorption of moisture and in order to increase the concentration of desiccant small amount of the mixture of water and liquid desiccant is pumped from conditioner basin to regenerator basin.

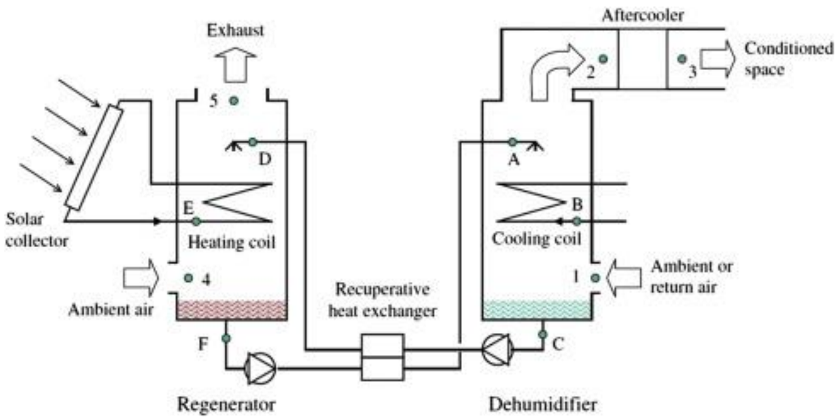

Figure5: Liquid Desiccant System

1.5 Closed Solar Cooling Sorption Cycle

Closed cycles are divided in two categories based on the sorption material as follow: Figure: 6 describes Closed Solar Cooling Sorption Cycle.

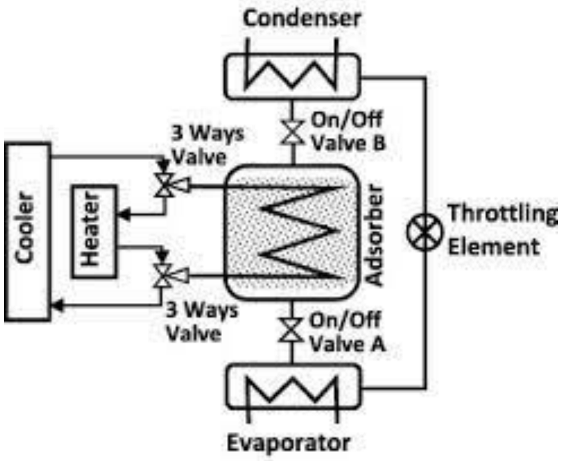

Figure6: Closed Solar Cooling Sorption Cycle

1.6 Solar Cooling Absorption systems

Absorption refrigeration cycles require hot water from waste heat .The history of an absorption cycle started in the 1700's. It was used to produces ice by an evaporation of pure water from a vessel placed within an evacuated container with sulfuric acid. Ferdinand Carre developed machine using water/ammonia as the working Fluid in 1859 while as system using LiBr/H_2O as the working fluid was developed in 1950 shown in Figure 7.

1.7 Adsorption Cooling System

Adsorption cooling is a one of most used thermal driven system. The energy source can be solar energy or waste heat from power plant. Figure 7 shows the major components of adsorption cooling system which consists of a thermal compressor, condenser, evaporator and expansion valve. The operation principle of an adsorption cooling device can be described as follows: Solar Heating System supply hot water to regenerate the sorbent in to the chamber 2, the hot water can be supplied from the external heat source like waste heat. The silica gel desorbed by hot water. The water vapor from the sorbent flows to the condenser where it is then condensed to a liquid state. The condensed water with high pressure flows through tubes and after reaching pressure level equal to that in the evaporator, so the water enters the evaporator where a system of nozzles is spraying water on the tubes of chilled water system. The water vapor entering from evaporator to adsorption chamber 1 through open valve at the bottom of the chamber. However to ensure vapor flow towards the absorbers, the pressure inside the chamber should be lower than that in the evaporator, therefore the chamber precooled and the cooling required to remove the heat added by the adsorption process. If the adsorbent in the adsorption chamber is fully saturated with water vapor, the chambers function is switched over. The process in adsorption system can be summarized. The below table and figure shows the difference between absorption and adsorption as follow: Absorption is when one molecule completely enters inside of a volume of other molecules.

It becomes a part of it. This can be a chemical or physical process. Absorption occurs when the physical state of the molecules has changed as a gas turns into a liquid, or a liquid into a solid. For example, LiBr can be absorbed into water – this is an example of a chemical absorption since a reaction occurs. Another example for a physical absorption is air dissolving into water this is since the air is entering into the water, driven by pressure difference. Adsorption, is a surface process when one molecule not entering completely inside of a volume of other molecules, its only attracting the molecules of a substance on the surface of a liquid or a solid that increasing the concentration of the molecules on the surface. This can be a chemical reaction chemical bonds used in sticking the adsorbate to the adsorbent or physical process (Figure 8). For example, The CO2 molecules just sit on the surface of the solid adsorbent. An endothermic reaction occurs when energy is absorbed from the surroundings in the form of heat. Conversely, an exothermic reaction is one in which energy is released from the system into the surroundings.

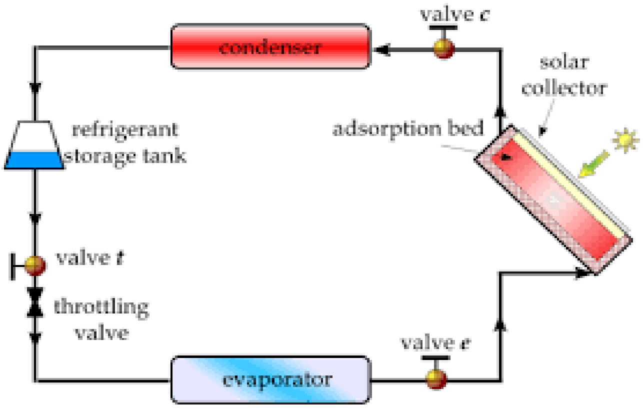

Figure7: Adsorption Cooling System

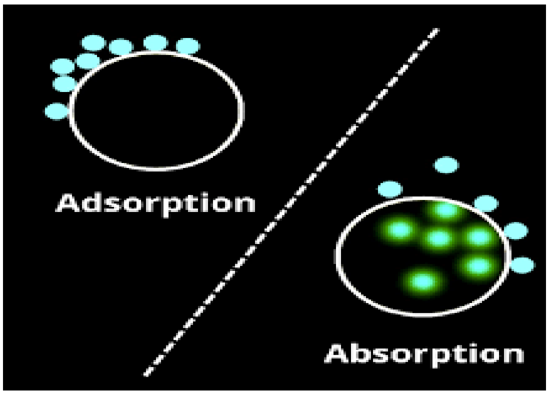

Figure8: difference between adsorption and absorption

1.8 Solar Energy Conversion System

The solar collector converts the solar energy from sunlight to thermal energy, The Thermal energy is then passed through high temperature energy storage tank then to the absorption system.

1.8.1 Evaporator

The building load is taken in the evaporator, as the water evaporate and the water vapor will pass to absorber. Inside the evaporator, relatively warm return water from the chilled-water system pass through the tubes. An evaporator pump draws the liquid refrigerant from the bottom of the evaporator and continuously circulates it to be sprayed over the tube surfaces This maximizes heat transfer. As heat transfers from the water to the cooler liquid refrigerant, the refrigerant vaporizes and the resulting refrigerant vapor is drawn into the lower pressure absorber. The evaporator and absorber are contained inside the same shell. The vacuum is created by hygroscopic action due to the strong affinity lithium bromide has for water makes the refrigerant to move to absorber.

1.8.2 Absorber

The Lithium bromide absorbs the water and form weak solution then it is passed to the generator through intermediate heat exchanger. Absorber types used for Lithium bromide-water system is absorption of vapor refrigerant into a falling film of solution over cooled horizontal tubes.

1.8.3 Generator

The hot water used to separate the weak solution form water vapor and form strong lithium bromide solution and then the water vapor is passed to the condenser. The hot water provided from Low-grade heat source can be upgraded by using solar energy [28], power plant waste heat or other industrial application. The absorption heat source performance with various working fluids has been investigated; LiBr/water, Dimethyl Formamide.

1.8.4 Heat exchanger

The strong solution of lithium bromide is passed to the absorber through heat exchanger after the separation in the generator. The weak solution from the absorber is pumped through the same heat exchanger to the generator, so the temperature of weak solution increased while as the strong solution temperature decreased.

1.8.5 Condenser

The cold water from cooling tower is used to remove the heat and condensate the water vapor, then the liquid water will enter the expansion valve.

1.8.6 Cooling water from cooling tower

Cold water supplied from cooling tower used to remove the heat from condenser and absorber then the heat is dissipated in the cooling tower to outside environment.

1.8.7 Auxiliary heat source

The auxiliary heat source is needed when sun is not shining or solar energy source is not enough to main continuous operation.

1.8.8 Performance of absorption solar cooling system

Cooling Capacity at evaporator COP = Heat Input at Generator +Pump Required Power The performance of Absorption solar cooling system depends mainly on thermodynamic properties of the working fluid.

II CONCLUSION

Many solar energy technology used to achieve refrigeration effect are investigated in this paper. This paper providing the useful indicators of these technologies performance. The paper presented the merits and demerits of the solar cooling technologies, a number of observations can be made as follow:

1. All sorption cycles including chemical sorption are in the process beginning with research laboratory to the market, but much more work is needed on cost minimization, design and packaging.
2. Small-scale absorption cycles driven by solar thermal energy have been recently launched in the market by several companies.

REFERENCES

[1]. Bernardo Peris Pérez, Miguel Ávila Gutiérrez, José Antonio Expósito Carrillo, José Manuel Salmerón Lissén, "Performance of Solar-driven Ejector Refrigeration System (SERS) as pre-cooling system for air handling units in warm climates", Energy, Volume 238, Part A, Doi: 10.1016/j.energy.2021.121647, Pg.no: 1-17, August 2021.

[2]. Jinyi Guo, Jose I. Bilbao, Alistair B. Sproul, "A novel solar cooling cycle – A ground coupled PV/T desiccant cooling (GPVTDC) system with low heat source temperatures", Renewable Energy, Volume 162, Doi: 10.1016/j.renene.2020.08.050, Pg.no: 1273-1284, August 2020.

[3]. Yongrui Xu, Zeyu Li, Hongkai Chen, Shiliang Lv, "Assessment and optimization of solar absorption-subcooled compression hybrid cooling system for cold storage", Applied Thermal Engineering, Volume 180, Doi: 10.1016/j.applthermaleng.2020.115886, Pg.no: 1-17, August 2020.

[4]. Maria T. Plytaria, Evangelos Bellos, Christos Tzivanidis, Kimon A. Antonopoulos, "Numerical simulation of a solar cooling system with and without phase change materials in radiant walls of a building", Energy Conversion and Management, Volume 188, Doi: 10.1016/j.enconman.2019.03.042, Pg.no: 40-43, March 2019.

[5]. R.M. Lazzarin, M. Noro, Past, "present, future of solar cooling: Technical and economical considerations", Solar Energy, Volume 172, Part 1, Doi: 10.1016/j.solener.2017.12.055, Pg.no: 1-12, December 2017.

[6]. Hegazy Rezk, Ahmed S. Alsaman, Mujahed Al-Dhaifallah, Ahmed A. Askalany, "Mohammad Ali Abdelkareem, Ahmed M. Nassef, Identifying optimal operating conditions of solar-driven silica gel based adsorption desalination cooling system via modern optimization", Solar Energy, Volume 181, Doi: 10.1016/j.solener.2019.02.024, Pg.no: 475-489, February 2019.

[7]. Muhammad Shoaib Ahmed Khan, Abdul Waheed Badar, Tariq Talha, Muhammad Wajahat Khan, Fahad Sarfraz Butt, "Configuration based modeling and performance analysis of single effect solar absorption cooling system in TRNSYS", Energy Conversion and Management, Volume 157, Doi: 10.1016/j.enconman.2017.12.024, Pg.no: 351-363, December 2017.

[8]. Javad Asadi, Pouria Amani, Mohammad Amani, Alibakhsh Kasaeian, Mehdi Bahiraei, "Thermo-economic analysis and multi-objective optimization of absorption cooling system driven by various solar collectors", Energy Conversion and Management, Volume 173, Doi: 10.1016/j.enconman.2018.08.013, Pg.no: 715-727, August 2018.

[9]. Jiyun Song, Behnam Sobhani, "Energy and exergy performance of an integrated desiccant cooling system with photovoltaic/thermal using phase change material and maisotsenko cooler", Journal of Energy Storage, Volume 32, Doi: 10.1016/j.est.2020.101698, Pg.no: 1-21, July 2020.

[10]. Amirreza Heidari, Ramin Roshandel, Vahid Vakiloroaya, "An innovative solar assisted desiccant-based evaporative cooling system for co-production of water and cooling in hot and humid climates", Energy Conversion and Management, Volume 185, Doi: 10.1016/j.enconman.2019.02.015, Pg.no: 396-409, February 2019.