STATE-OF-THE-ART REVIEW ON A SOLAR ABSORPTION COOLING SYSTEMS

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ABSTRACT

solar cooling is considered attractive because solar radiation is in phase with cooling demand .One of the technologies for applying solar cooling is absorption systems. solar cooling effectiveness needs to be evaluated based on various performance indicating parameters. Type of collectors should be carefully selected to make solar absorption cooling system more attractive from energy and cost view point. Several solar thermal cooling performance, developments, including the cost and feasibility, are presented and discussed.

Keywords: *Solar energy,absorption system,thermal cooling*, *water/lithium bromide*

1. INTRODUCTION

Recently, many studies have been carried out in the development of absorption cooling prototypes operating with ammonia/water [1] and water/lithium bromide [2–9]. These two mixtures have been the most used since they have great advantages; however they have some disadvantages. for these reasons many studies have been focused in the developpment of new absorption cooling working fluid that present best property than conventionnel binary fluids.

Initial solar cooling possibilities operating with solar energy were investigated by Tabor [10] .It can be classified as electric and thermal powered systems. The main thermal solar cooling systems are; absorption,adsorption, and desiccant. These systems can operate with low energy source and environmental friendly refrigerants.It is showed that solar thermal cooling systems is less performent than electric cooling system using PV [11]. Furthermore, energy conversion using thermal cooling system is significantly more attractive than solar energyconversion by PV systems [12].

2. SOLAR THERMAL COOLING

The most common solar electricity driven cooling technology is a vapor Compression Cycle (VCC) driven by a Photovoltaic (PV) system. PV solar cooling is suitable and requires low maintenance [13] , but production by PV is limited to sunshine hours only. However, storage of cooling produced during the sunshine hours for later use is a promising solution. [14]. The results showed that in solar thermally driven cooling systems, the heat from a solar collector can be used to produce mechanical power to compress the refrigerant vapor in VCC. single effect absorption chillers with LiBr are the most commercially developed [15, 16, 17, 18, 19 ,20].

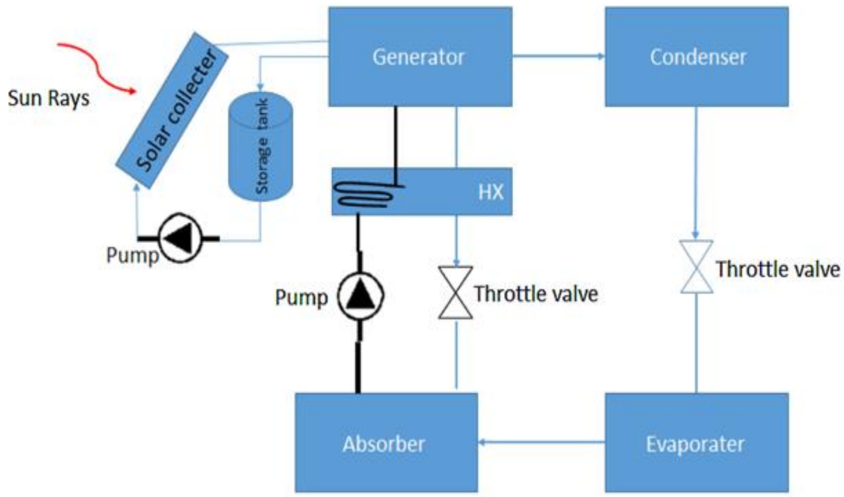

FIGURE1. Configuration of solar thermal sorption cooling system

It is composed of two circuits:the refrigerant circuit from generator to absorber and LiBr–water solution circuit from the absorber to generator through the heat exchanger. Among all absorption chiller types, single effect absorption chiller has a simple configuration and fewer components figure 1.It can be used for both air conditioning and freezing application.

3. EFFECT OF COLLECTOR TYPES

Concentrating collectors use only the direct normal irradiance (DNI) as opposed to FPCs and ETCs which can also harvest solar diffuse radiation. to make solar absorption cooling system more attractive from energy and cost view point , a careful selection of collectors should be carried out . studies indicated that the best choice for solar collector type is related to several factors such as; number of absorption effect, solar radiation level and percentage of DNI. Mass production of efficient solar collectors will reduce their cost and help the cooling system to be cost competitive with the conventional cooling technologies [21]. The effect of solar collector types on the performance of solar absorption systems has been examined [22]. Their results showed that parabolic collector is the best choice for the absorption system. However, the authors did not estimate the fraction of DNI to the defuse irradiation. the evacuated flat plate collector powered double-effect absorption chiller is thermally efficient [23] . The double-effect chiller with evacuated flat plate collectors [24] show a good energetic and economic performance under different climatic conditions. The triple-effect chiller with parabolic trough collectors gives the most energy-efficient and cost-effective plant.Reduction in the total cost and an increased COP of the system can be obtained using concentrated solar cooling systems with higher source temperature [16]. Medium temperatures applications (solar cooling) are presently supplied mostly by evacuated tube heat pipe solar collectors that have some disadvantages like low thermal efficiency at medium to high temperature range. high concentrating compound parabolic concentrators and numerous evacuated tube heat pipe solar collectors use permit to reach Medium temperatures needed for solar cooling. Currently, evacuated tube heat pipe solar collectors and the flat plate collectors are used to operate solar thermal air-conditioning systems and other medium temperature applications. It has been noted that evacuated tube solar collectors have low heat dissipation compared to convectional flat plate due to the fact that the absorber is vacuum enveloped [25,26 ,27, 28, 29].

4. EXPERIMENTAL STUDIES

Solar cooling technologies have been the object of experimental analysis. The analysis were based on the needed generator input temperature. Based on this, it is considered that solar collectors designed and tested as a critical component for solar cooling absorption systems. Along with aqua-ammonia systems, several experimental studies have been carried out concerning the LiBr–water systems . Much of the experimental work have also been conducted over LiBr–water systems [30]. Experimental analysis of a domestic-scale 4.5 kW solar powered LiBr–water absorption system equipped with a 1000 l cold storage was performed by[31] .Vacuum tube solar collectors were used with the collector area of 12 m^2 in the experiment. The experimental results indicated a COP of 0.58 while producing the chilled water at a temperature of 7.4 C° in the cold storage. The experimental analysis of a LiBr– water absorption system powered by evacuated tubular and flat plate solar collectors and integrated with four hot water storage tanks was studied by[32]. Their experimental results indicated that a COP of 0.69 could be achieved when supplied by the heated water at 96.3 1 C° by the solar collectors. Table 1 shows experimental evaluation of binary fluid in absorption cooling systems.

Authors	Year	Fluid
Agarwal and Bapat	1985	DMF/R22
Herold et al.	1991	NaOH–KOH– CsOH/Water
Hou and Tan	1992	LiBr/Water
Iyoki and Uemura	1989	LiBr/Water
Iyoki and Uemura	1990	LiBr–ZnBr2– LiCl/Water
Jeter et al.	1992	LiBr/Water
Lenard et al.	1992	LiBr/Water
Patterson and Perez-Blanco	1998	LiBr/Water
Wen and Lin	1992	LiBr/Water
Zaltash et al.	1991	LiBr/Water

Table 1 indicates some experimental of different binary fluid in absorption cooling systems.

5. SIMULATION ANALYSIS

Simulation studies aims to predict the performance of solar cooling systems before the design and experimental evaluation. Besides aqua-ammonia, the LiBr– water represents another commonly used refrigerant–absorbent working pair in solar powered absorption refrigeration system. Simulation studies were carried out. Recently, a simulation study related to this subject using the mathematical code developed in FORTRAN simulation software was presented [33]. In this study, he draws a comparison between single effect and double effect absorption systems. His results showed that the double effect systems have COP approximately double to that of single effect systems. His case study revealed a COP of 1.22– 1.42 for the double effect systems where the single effect system could only reach a COP of 0.73–0.79 when operating under the same conditions. He also measured the optimum generator temperature. MATLab software was used by [34] to simulate the hourly performance. Their results showed that the total exergy loss in the collector are between 10 to 70% which is higher than the other components of solar absorption cycle carried out a parametric study of the COP of the LiBr–water system under variable operating parameters was carried out by [35]. The results indicated that solution heat exchanger increases the coefficient of performance by 44% compared to refrigerant heat exchanger . Both the 1st law and 2nd law thermodynamic analysis of LiBr–water system for single effect, double effect and triple effect systems were performed [36] . He showed that the maximum second law efficiency for (single double and triple) effect systems are in the range of 0.125–0.232, 0.143–0.251 and 0.177–0.252 respectively. The 1st law results show that the COP of series flow double effect cycle is 60 to 70% greater than the single effect cycle [37]. The 1st and 2nd law thermodynamic analysis of LiBr– water absorption chiller were steadied by [38]. The results revealed that irrespective of the working conditions, the generator presents the highest exergy loss component.

6. CONCLUSION

Solar thermal systems can be used to produce cooling. It has positive economic,environmental, and social effects on human life. Solar thermal absorption systems are feasible for industrial or domestic applications,considering that solar radiation is unlimited and available in most parts of the world.Designed and tested solar collector is a critical component for solar cooling absorption systems.The study reveals that evacuated tube collectors are best option for solar cooling than the other types and the double-effect absorption chiller with evacuated flat plate collectors show a good energetic and economic performance under different climatic conditions.In other hand, in spite of, there are various working fluids that have theoretically shown good performance, there is still a need to experimentally verify it.

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