International Conference on Applied Energy 2019
Aug 12-15, 2019, Västerås, Sweden
Paper ID: 0691

SOLAR COOLING TECHNOLOGY: RECENT DEVELOPMENT AND FUTURE ASPECTS

Sunita Mahavar, Ankit Goyal, Mohsin Khan

Department of Physics, University of Rajasthan, Jaipur 302004, India

ABSTRACT

In world's context the energy consumption for air conditioning and cold is rising year by year. Solar cooling is one of the most promising solutions to the worsening energy and climate issues. It can provide a sustainable active air-conditioning possibility due to reduce greenhouse gas emission as well as electricity consumption. This paper discusses current development and future aspects of solar cooling technology. The selection of adsorbent-adsorbate materials and solar collector are important to improve the solar cooling system. It is revealed in review that coefficient of performance (COP) of solar flat plate collector technology are still insignificant in range as well as systems are not economically viable. The use of highly efficient integrated solar concentrator systems able to achieve temperature up-to 180°C can increase the COP by a significant amount and can pave a path to the future of this technology.

Keywords: Solar cooling, Paraboloid solar concentrator, Absorption chiller, Evacuated tube collector (ETC),

1. INTRODUCTION

In recent years, the sale figures of electrically driven compressor chillers (split units) have raised rapidly to 100 million units per year sold [1]; indicating huge energy consumption in cooling sector. Solar heating and cooling systems are a promising technology which may significantly contribute to enhancement of energy efficiency, and the increase of renewable share in the building cooling sector. There is a direct match of the peak incident solar radiation with the solar cooling needs, both in seasonal and daily variations which is a merit for the solar technology. The heating and cooling system performance is also better for high collected incident solar radiation [2]. So far, five main solar concentrator technologies can be identified: (i) Compound Parabolic Concentrator (CPC) (ii) Parabolic Trough Concentrator (PTC) (iii) Linear Fresnel Reflector (LFR) (iv) Parabolic dish with fixed focus (v) Parabolic dish with moving focus [3], that can be used for future solar cooling technologies. Presently, Flat Plate Collector (FPC), the Evacuated Tube Collector (ETC), Linear Fresnel Reflectors (LFR) and Parabolic Through Collectors (PTC) have been implemented by a number of researchers for the absorption systems that can be divided into three categories: single-effect, half-effect and double-effect solar absorption cycles. In view of a detailed literature review there is still the need for more research on solar sorption systems to make them both cost and energy competitive with the solar cooling technologies.

2. CURRENT STATE-OF-ART OF SOLAR COOLING

2.1. Solar cooling

The thermally powered refrigeration technologies are classified into two main categories: sorption technology (open systems or closed systems) and thermo-mechanical technology (ejector system). Solid and liquid desiccant cycles represent the open system. Absorption and adsorption technologies represent the closed system. The adsorption cooling typically needs lower heat source temperatures than the absorption cooling. Based on COP, the absorption systems are preferred to the adsorption systems [4]. The history of an absorption cycle started in the 1700's. The Absorption cooling uses thermal energy to produce cooling and thus solar energy, waste heat and other forms of low grade heat can be employed. Schematic figure of solar thermal cooling technology is plotted in Fig. 1. A solar thermal refrigeration system consists of four major components:

a solar collector, a tank for thermal storage, a thermal AC unit and a heat exchanger as shown in Fig. 2.

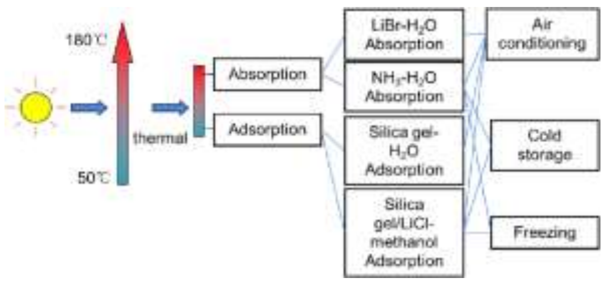

Fig. 1. Solar thermal cooling technologies [5].

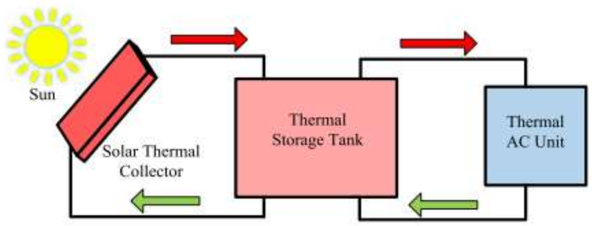

Fig 2. Working of a solar thermal cooling system [4]

2.2. Current development

A number of references are referred here for current development in solar technology for cooling. Palomba et al. [6] have reported that a high number of papers aiming at investigating solar heating and cooling systems based on heat driven and solar technologies, configurations, operating strategies, and financing issues. Bataineh and Taamneh [7] presented a comprehensive literature review of solar sorption systems. Most of the solar cooling systems are based on single absorption chillers and use the Flat Plate Collector (FPC) or the Evacuated Tube Collector (ETC) as solar thermal technology as reported by Chemisana et al. [8]. Similar is also noted by Nkwetta, and Sandercock [2].

3. CONCENTRATED SOLAR TECHNOLOGY: THE FUTURE OF SOLAR COOLING

A number of researchers have worked on combining different cooling technologies along with different solar thermal technologies viz. flat plate collector, trough solar collectors, Evacuated tube collectors, concentrating Fresnel collectors, compound parabolic concentrator etc.

Concentrating solar collectors are promising to demonstrate the achievement of higher efficiency in thermally driven cycles as mentioned in different review papers [5, 8].

Different solar cooling technologies and parameters are summarized from a few references and are depicted in Table 1. Review details will be presented in full length paper.

Table 1: Solar cooling technologies and parameters

Reference	Tech-nology	COP	Fluid	Temp. (ºC)
Hildbrand C.	FPC	0.1-0.25	-	-
Sumathy	FPC	0.07	LiBr-H_2O	75-100
Calise	FPC	-	LiBr-H_2O	80
Luo H.L	ETC	0.1-0.13	Silica get water	-
Pongtornkulpanich	ETC	-	LiBr-H_2O	70-95
Berhane H.G	CPC	0.3	-	-
Dawoud B.	LFR	1.1-1.25	Water	-
Lazzarin R.M	FPC	15%	H_2O-NH_3	70
	ETC	40%		90
	PTC	55%		160
Omisanya N.O	CPC	0.838-1.48	Zeolite-water	110
Li T.X	PTC	0.13-0.22	$SrCl_2/NH_3$	90-100
Tashtoush G.M	PTC	0.375	Activated carbon methanol	157

4. RESULTS AND DISCUSSION

The selection of adsorbent-adsorbate materials & solar collector is important to improve the solar cooling system. Traditional flat plate, evacuated tube and highly efficient parabolic trough collector can provide temperature of 60–80 °C, 80–150 °C and 150–300 °C respectively. Higher temperature generated by concentrated solar collectors appears to be economically viable for solar cooling systems. This study reveals that: For higher COP than 0.3 the use of concentrated solar collectors is much effective than flat-plate collector or an evacuated tubular collector. It is also noticed solar thermal concentrating collectors are still a rather new technology and needed in implementation in future for cooling. In principle, a noticeable potential also exists for cost reduction of solar thermal collectors. The use of highly efficient integrated solar concentrator systems able to achieve temperature up to 180 ^{0}C, can increase the coefficient of performance (COP) of cooling system by a significant amount.

5. CONCLUSION

Traditional flat plate, evacuated tube and high efficient parabolic trough collector can provide temperature of 60–80 °C, 80–150 °C and 150–300 °C respectively. Higher temperature generated by concentrated solar collectors appears to be economically viable for solar cooling systems. The use of high efficient integrated solar concentrator systems able to achieve temperature up to 180 ^{0}C, can increase the coefficient of performance (COP) of cooling system by a significant amount.

ACKNOWLEDGMENT

Authors are thankful to DST (New Delhi) and SERB (New Delhi) for project fund under those this study is conducted.

REFERENCES

[1] Shah N, Wei M, Letschert V, Phadke A. (2015) Benefits of Leapfrogging to Super efficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning, U.S. Department of Energy under Lawrence Berkeley National Laboratory. Accessed on 31/10/16 at <http://eetd.lbl.gov/sites/all/files/lbnl-1003671_0.pdf>.

[2] Nkwetta DN, Sandercock J. A state-of-the-art review of solar air-conditioning systems. Renewable and Sustainable Energy Reviews 2016;601351-66.

[3] Mahavar S, Sethi, R, Khan MS. Fabrication and Testing of a Paraboloidal Solar Concentrator for Low Temperature Applications, 9th World Renewable Energy Technology Congress & Expo-2018, 21st to 23rd August 2018, Pravasi Bhartiya Kendra, Delhi, India.

[4] Sarbu L, Sebarchievici C. Review of solar refrigeration and cooling systems. Energy and Buildings 2013;67:286-97.

[5] Ge TS, Wang RZ, Xu ZY, Pan QW, Du S, Chen XM, Ma T, Wu XN, Sun XL, Chen JF. Solar heating and cooling: Present and future development. Renewable Energy 2018;126:1126-40.

[6]Palomba V, Vasta S, Freni A, Pan Q, Wang R, Zhai X. Increasing the share of renewables through adsorption solar cooling: A validated case study. Renewable Energy 2017;110:126-140.

[7] Bataineh K, Taamneh Y. Review and recent improvements of solar sorption cooling systems. Energy and Buildings 2016;128:22-37.

[8] Chemisana D, Villada JP, Coronas A, Rosell JI, Lodi C. Building integration of concentrating systems for solar cooling applications. Applied Thermal Engineering 2013; 50(2):1472-79.