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Solar adsorption cooling and hot water supply for climatic condition of Dhaka

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Abstract

For the climatic condition of a tropical country like Bangladesh, solar heat driven adsorption cooling seems to have great prospect. Installation cost is one of the foremost drawbacks of such a system. Although, once installed, system maintenance and operation cost is negligible. Besides, the solar unit can not only support as a cooler for adsorption space cooling purpose during summer season but also as a source of hot water supply for domestic use during the winter season. A conventional two bed basic adsorption chiller, driven by solar heat run by silica gel-water pair as adsorbent and adsorbate respectively, has been investigated for the climatic condition of Dhaka $23^\circ 46'$ N (latitude), and $90^\circ 23'$ E (longitude). 30 enhanced compound parabolic concentrator (CPC) collectors each of area 2.415 m^2 along with a hot water storage tank of volume 2.197 liters is optimum for considered climatic condition. With such a unit 30.27°C continuous water supply during the peak hours can be assured, with the storage of 44.77°C of hot water in the month of January.

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Keywords: Solar heat; adsorption cooling; storage tank; hot water supply; renewable energy.

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1. Introduction

Growing population, shortage of primary resources and demand of the modern generation ask for new ideas to search for environment friendly technologies that are easily available and within the reach of mass population. Solar radiation is known to be the largest and the world's most abundant permanent and clean energy source. Compared to the annual global energy use, the amount of solar radiation intercepted by the earth's surface is much higher. In full sun, it can be safely assumed about 100 watts of solar energy per square foot [1]. If 12 hours of sun per day is assumed, this is 438,000 watt-hours per square foot per year [1]. In recent years, many promising technologies have been developed to extract sun's energy. One of these important technologies is the solar refrigeration systems which employ either absorption or adsorption technologies. Solar adsorption refrigeration devices are extremely important for vaccine and food preservations in remote areas. Due to the ability to combat against ozone depletion problem which was caused by the utilization of CFCs and HCFCs in cooling systems, thermally powered adsorption refrigeration system has gained considerable interest in recent years [2].

Absorption, adsorption and desiccant cooling are the most common technologies available in solar refrigeration and air-conditioning applications. Solar powered adsorption cooling systems, in particular, have the advantages of using clean energy and environment friendly refrigerants. Moreover, they can be driven by low temperature heat source, typically below 100° C, which can be reduced to 50° C if multi-stage scheme is performed [3- 5].

Pons and Guilleminot [6] studied solar powered adsorption system employing activated carbon-methanol pair to produce ice. Anyanwu and Ogueke [7] and Anyanwu and Ezekwe [8] studied transient analysis of solid adsorption solar refrigerator applying activated carbon-methanol as adsorbent-refrigerant pair. Sumathy et al. [9] employed activated carbon-methanol pair to study solar driven two bed adsorption air-conditioning system. Boubakri [10,11] reported new conception of adsorptive solar powered icemaker equipped with a single heat exchanger playing alternatively the role of condenser and evaporator. It shows that the daily ice production may exceed 5.2 kg, with a COP of more than 0.14 with a consistent design of the different components of adsorptive solar machine.

In the recent years, a number of researchers have investigated various aspects of solar adsorption cooling and refrigeration system like Clauss et al. [12] and Alam et al. [13]. Also for climatic condition of southern Asia mainly tropical regions [14,15] . Based on the climatic condition of Dhaka, Rouf et al. [16] investigated performance on collector area and cycle time for solar driven adsorption chiller. Later effect of the operating conditions on the performance of the system has been studied for the same conditions [17]. Lately, performance of an adsorption cooling system added with a storage tank has been discussed by Rouf et al. [18] for climatic condition of Dhaka. The present study investigates the prospect of the installation of optimum collector area only for hot summer season but also for cold winter as well as hot water supply for winter.

Nomenclature				**Subscript**	
A	area	$\dot{m}$	mass flow rate	cp	collector pipe
W	weight	η	collector efficiency	cr	collector
C	specific heat	U	heat transfer coefficient	tm	tank metal
T	temperature	I	solar radiation	wt	tank water

2. System description

For the climatic condition of Dhaka (Latitude $23^{\circ}46'$N, Longitude $90^{\circ}23'$E) a conventional single stage basic adsorption chiller with two beds coupled with CPC solar collectors has been discussed in Rouf et al. [13]. The working principle of same chiller when added with a storage tank is available in Rouf et al. [18]. For both cases silica gel -water pair has been considered as adsorbent and adsorbate respectively. The basic adsorption cycle