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Development of a continuously operating solar-driven adsorption cooling system: Thermodynamic analysis and parametric study

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ABSTRACT

A novel solar-driven adsorption cooling system that is able to produce cold continuously along the 24-h of the day is proposed in this study. The working principle of the proposed system is based on the constant temperature adsorption cooling cycle which is introduced also in this work. Both of the cooling system principle of operation and the cycle description are explained in details. Moreover, complete thermodynamic analysis is performed for all components of the system as well as processes of the theoretical cycle. Activated carbon-methanol is used as the working pair in the case studied. Furthermore, a parametric study of the influence of many system parameters on the performance is accomplished and discussed as well.

1. Introduction

Energy is considered the continuous driving power for economic growth and the major requirement for technological developments. The increasing rate of population, industry, and the per capita energy consumption are the major forces that cause the increase in energy demand during the coming years. However, the conventional energy types are neither reliable nor sustainable and the world's reserves of oil are not large enough to be dependable in the near future. As a consequence, securing sustainable and renewable resources of energy with reasonable costs and without adverse impacts on our environment are the challenge. From this point, solar energy comes at the top of the list due to its abundance and more equal distribution in nature than other types of renewable energy. There are currently several rapid expanding technologies that are used to harness the sun's power. These include power generation, solar water heating and desalination, cooking and food drying, space heating, cooling and refrigeration, and others.

Cooling, refrigeration, and air conditioning processes mainly contribute in a considerable number of fields of human life. However, the traditional vapor compression machines are dominating electricity consumers and their operation and propagation cause high electricity peak loads during the summer, especially in those countries with tropical climate. The energy consumption for air conditioning systems has recently been estimated to be 45% of the whole households and commercial buildings, Choudhury et al. [1]. That is besides, the conventional vapor compression systems use non-natural refrigerants that have high global warming as well as ozone layer depletion potentials due to the fluorocarbons. Consequently, Providing cooling by utilizing a green energy such as solar energy is the key solution to both energy and pollution problems. The Mediterranean countries may save 40–50% of their energy used for air conditioning by implementing solar-driven air conditioning systems, Balaras et al. [2] and Abu Hamdeh and Al-Muhtaseb [3].

The development of solar refrigeration technologies became the worldwide focal point for concern because the peaks of requirements in cold coincide most of the time with the availability of the solar radiation. One of these mature technologies is the solar powered adsorption refrigeration technology which is proven to be suitable and applicable for refrigeration as well as air conditioning applications. The refrigerants used in these systems are environmentally benign, natural refrigerants and are free from CFC. Therefore, these systems have zero ozone depleting as well as

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