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Numerical Analysis of Solar Refrigerating System Performances

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ABSTRACT

In this preset work, we investigate the solar and the thermal performances of the adsorption refrigerating system, considering an annular and plate finned configurations of the adsorber using BPL-ammonia as an adsorbent-adsorbate pair. The obtained results show that, for the two working pairs, the increase of the fins number corresponds to the decreasing of the heat losses towards environmental and the increasing of heat transfer inside the adsorber. The system performances are sensitive to the fins geometry. For the considered data measured for a clear type day of September 2023 in Algeria, the performances of the cooling system are very significant.

Keywords: Refrigerating System, Solar energy, Adsorption, BPL-ammonia pair

1. Introduction

Solar Energy source is a sustainable, a totally inexhaustible and environmentally friendly alternative to the fossil fuels available. It is a renewable and an economic energy that can be harnessed sustainably over a long term and thus stabilizes the energy costs. Solar cooling technologies have been developed to decrease the augmentation electricity consumption for air conditioning and to displace the peak load during hot summer days [1]. In the field of sorption cooling, there are different kinds of system: solid absorption, liquid absorption and adsorption system. The advantage of the adsorption cooling systems over the absorption ones is that they have a simple structure. The system consists essentially of an evaporator, a condenser and an adsorbent that is the object of this work (figure 1). To optimize the system, many models have been proposed. However, the earlier models which may be classified either as uniform temperature models [2] or as uniform pressure models [3,4], considered only heat transfer while neglecting mass transfer in the adsorbent. It is only recently that a number of numerical studies with consideration of coupled heat and mass transfer have been presented [5].

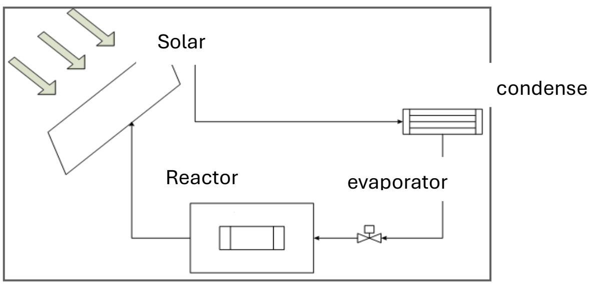

Figure 1: Schematic of the System

For this context, in this preset work, two different configurations of reactors are considered to investigate the performance of a solar refrigerating system using BPL-ammonia adsorbent-adsorbate pair. The results show that, for the two working pairs, the increase of the fins number corresponds to the decreasing of the heat losses towards environmental and the increasing of heat transfer inside the adsorber. The system performances are sensitive to the fins geometry. For the considered data, the performances of the cooling system are very significant.

DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)

2. Mathematical Model

The general equation in the adsorber is:

$$\frac{\partial}{\partial t}((\rho C)_e T)+\vec{V}.\vec{\nabla}(\rho_g C_g T)=\vec{\nabla}(\lambda_e \nabla T)+S \qquad (1)$$

$$(\rho C)_e=\rho_s C_s(1-\varepsilon)+\rho_g C_g(\varepsilon-\alpha)+\rho_a C_a \alpha \qquad (2)$$

$$S=\frac{\partial}{\partial t}[(\varepsilon-\alpha)\rho_g]\frac{P}{\rho_g}+\left(\frac{P}{\rho_a}+\Delta H_{ads}\right)\times \quad \rho_{app}\frac{\partial m_a}{\partial t} \qquad (3)$$

Where α is the volume fraction of the adsorbed phase, ρ_i and C_i are the density and specific heat of the phase i, ε is the porosity of the activated carbon, ρ_{app} is the adsorbent density, m_a is the mass quantity, ΔH_{ads} is the heat of sorption and λ_e is the equivalent thermal conductivity. The convective term is assumed negligible compared to other terms in (1). A thermodynamic model is used to calculate the adsorbed quantity in the case of activated carbon (BPL)/ammonia

3. Results and Discussion

The modeling of the adsorption cooling system requires the resolution of the equation describing the energy and mass transfer in every element of the system, using activated carbon BPL-ammonia pair. Figure 2 illustrate the evolution the solar performance coefficient (COPs), that represents the ratio of the cooling power to the incident global irradiance during the whole day, for the considered solar data measured for a clear type day of September 2023. We notice that the COPs increases with the increase of the generating temperature. The solar performances of the cooling system are better in the case of the annular adsorber compared to the plate adsorber case.

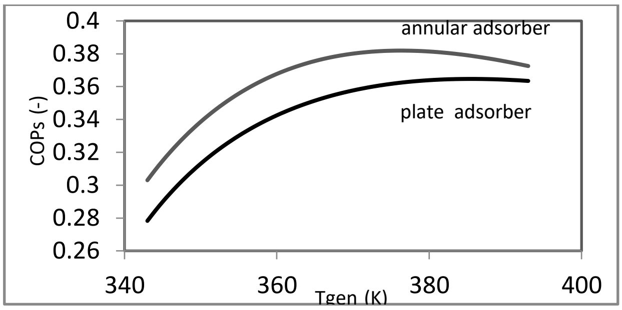

Figure 2: COPs variations versus generating temperature

4. Conclusions

In this presented work, we have considered a model taking in account the heat and mass transfer in the collector of the system. The model simulating the real working of a solar adsorption cooling system takes in account all balances of energy and mass for every element of the machine. We have studied two different configurations: a plate and annular adsorbers with fins, using activated carbon (BPL)-ammonia pair. We have notice that the solar and thermal performances of the system are better in the case of the annular configuration.

5. References

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ISBN: 978-81-970666-4-1
Series: AIJR Abstracts
DOI: 10.21467/abstracts.169