Solar Powered Adsorption Refrigeration System

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1. Introduction

Solar power is an environment-friendly source of energy which is abundant in nature. It also has the potential of reducing the world's demand for fossil fuels. It is particularly attractive for use in adsorption refrigeration systems in areas of the world where electrical power is scarce and where there is a plentiful source of solar energy. Since there are few/no moving parts, the consumption of any mechanical energy is minimized. Such refrigeration systems function on the basis of adsorption and desorption which are the accumulation and release of gases (adsorbate) into a solid substance (adsorbent), respectively. Solar powered adsorption refrigeration systems (SPARS) have the advantage of being thermally-driven as well as the ability of operating with low-grade heat energy. In such systems, the compressor of a conventional refrigeration system is replaced by an adsorber. Moreover, SPARS are promising solar refrigeration method and have low maintenance and operating expenses. This paper focuses on the possibility of using the solar adsorption refrigeration technology for air-conditioning purposes in the UAE.

2. Key Features

Principle of adsorption refrigeration cycle

Fig. 1 illustrates an ideal adsorption cycle which is best described by a Clapeyron diagram. This cycle can be summarized in four thermodynamic steps:

- Step 1: Isosteric heating (A → B). Solar irradiance is used to increase the system's temperature and pressure until the condenser pressure P_C is reached.
- Step 2: Desorption (B → D) + Condensation (B → C). Desorption of adsorbate (refrigerant) contained in the adsorbent; Condensation of the refrigerant in the condenser.
- Step 3: Isosteric cooling (D → F). The refrigerant reaches the evaporator pressure P_E.
- Step 4: Adsorption (F → A) + Evaporation (E → A). Evaporation of the refrigerant in the evaporator and adsorption of the refrigerant by the adsorbent.

In Fig. 1, T_E is the evaporator temperature and depends on the application. T_C is the condenser temperature. T_A is the temperature at the end of adsorption. It should be as low as possible so that the concentration is as high as possible. As a result, the quantity of adsorbent used is minimized. T_B is the temperature at the start of desorption. T_D is the temperature at the end of desorption which is a design variable.

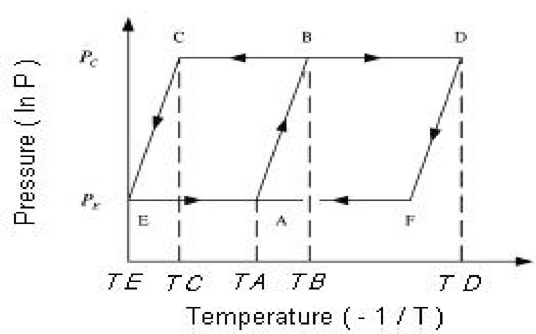

Fig. 1. Clapeyron diagram of ideal adsorption cycle.

For air conditioning, Table 1 shows the typical values for T_E, T_A and T_B [1]. In the UAE the maximum temperature, T_D, can be easily obtained by a thermal solar collector.

Table 1. Typical values for T_E, T_A and T_B for air conditioning applications.

Application	Ambient Temperature	T_E (°C)	T_A (°C)	T_B (°C)
Air Conditioning	Hot	5	45	91

A schematic of a novel experimental set-up to study the performance of the adsorption cycle is shown in Fig. 2. The hot/cold water sources are used to accomplish desorption/adsorption process in adsorbers A and B simultaneously.

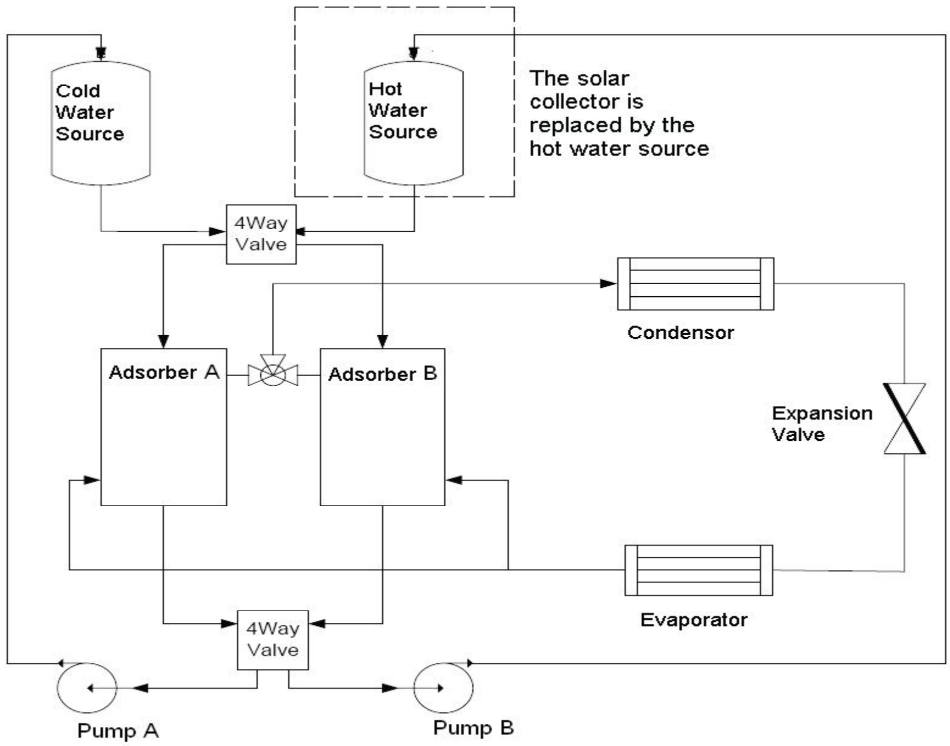

Fig. 2. Schematic of a novel experimental set-up to study the performance of the adsorption cycle.

3. Conclusions

This paper briefly outlined the processes of desorption and adsorption and the motivations for adsorption cooling for air conditioning purposes. Currently, the solar energy available for the UAE is being studied at the Petroleum Institute, UAE. The SPARS presented is attractive for future research and development. Existing solar refrigeration systems are not yet competitive with electricity-driven refrigeration systems. Therefore, research activities should be conducted to reduce collector area, improve system performance and reduce collector cost.

4. References and Bibliography

1. Critoph, R.E, 1988, "Performance Limitations of Adsorption Cycles for Solar cooling," Solar Energy, vol. 41, pp. 23.

Author Biography

Mr. Ali Al Alili is a Research Assistant in the Mechanical Engineering Program at the Petroleum Institute (PI), Abu Dhabi, UAE. He was a Honor Student at Arizona State University, USA, where he earned his B.S. degree in Mechanical Engineering. His current research interest is solar cooling techniques.