



## The role of activated carbon fiber in adsorption cooling cycles

Dalia Attan<sup>a</sup>, M.A. Alghoul<sup>b,\*</sup>, B.B. Saha<sup>c</sup>, J. Assadeq<sup>b</sup>, K. Sopian<sup>b</sup>

<sup>a</sup> UiTM Cawangan Negeri Sembilan, Kampus Kuala Pilah, 72000 Kuala Pilah, Malaysia

<sup>b</sup> Solar Energy Research Institute, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

<sup>c</sup> Mechanical Engineering Department, Kyushu University, 744 Motoooka, Nishi-ku, Fukuoka 819-0395, Japan

### ARTICLE INFO

#### Article history:

Received 26 May 2010

Accepted 26 October 2010

Available online 28 January 2011

#### Keywords:

Activated carbon fiber (ACF)

Adsorption characteristics

Adsorption cooling technology

### ABSTRACT

Researches on activated carbon fiber (ACF) in adsorption cooling system are important. ACF as adsorbent offers solution to shortcomings in solar adsorption refrigeration technology. By having ACF, rapid adsorption/desorption time and higher adsorption capacity per unit mass of adsorbent can be achieved. This review paper covers and provide an up-to date research that has been devoted to advancing of various types of activated carbon fiber as adsorbent in adsorption cooling. Detailed adsorption capacity, the effect of packing density, option of adsorption cycle and various innovation of adsorbent bed employing activated carbon fiber are highlighted since these results promise heat and mass transfer improvement of the adsorbent bed. Subsequently the coefficient of performance (COP) and specific cooling effect (SCE) of adsorption cooler are improved. This particular adsorbent could help solar adsorption refrigeration technology to compete with conventional vapor compression system if its properties are further improved.

© 2010 Elsevier Ltd. All rights reserved.

### Contents

1. Introduction.....	1709
2. Porosity standard test.....	1709
3. ACF and adsorbate.....	1710
3.1. ACF–ammonia.....	1710
3.2. ACF–acetone.....	1710
3.3. ACF–methanol.....	1710
3.4. ACF–water.....	1710
3.5. ACF–carbon dioxide (CO <sub>2</sub> ).....	1710
3.6. ACF–gasoline vapors.....	1710
3.7. ACF and ethanol.....	1711
3.7.1. Adsorption capacity.....	1711
3.7.2. Adsorption cooling potential of ACF.....	1711
3.7.3. Bed apparent density.....	1711
4. ACF in adsorption cooling cycle.....	1712
4.1. Types of cycle.....	1712
4.2. Adsorber bed design.....	1715
5. ACF composite.....	1718
5.1. ACF composite adsorbent.....	1718
5.2. ACF composite adsorbent in cooling cycle.....	1720
6. Conclusion.....	1720
Acknowledgements.....	1721
References.....	1721

\* Corresponding author.

E-mail address: [dr.alghoul@gmail.com](mailto:dr.alghoul@gmail.com) (M.A. Alghoul).

## 1. Introduction

Cooling is simply a process of reducing the temperature of a space or product for purposes of either comfort or preservation. It can be accomplished by various methods, using different types of energy ranging from electrical to mechanical or even purely thermal energy. Thermal energy could be fossil fuel derived, biomass derived or solar radiation [1].

The solar adsorption cooling systems are employed to meet the demands of cooling requirements such as air conditioning, ice making and medical or food preservation in remote areas. Quite, non-corrosive, environmental friendly, low cost and low maintenance of operations are the remarkable characteristics of the technology.

Adsorption capacity of working pair is an imperative indicator of adsorption cooling. High adsorption capacity results better cooling effect thus improve the performance of adsorption refrigeration. Adsorption capacity of working pair depends on the porous properties (surface area, pore size and pore volume) of the adsorbent and isothermal characteristics of the working pair.

## 2. Porosity standard test

Linares-Solano and Cazorla-Amoros [2] reported in their review that the evaluation of porosity of a particular adsorbent by physical adsorption of gases is the most widely used technique. Different adsorptive such as nitrogen ( $N_2$ ), carbon dioxide ( $CO_2$ ), Argon (Ar), helium (He),  $CH_4$ , benzene and nonane can be used for this purpose. Due to the considerable sensitivity of nitrogen adsorption isotherms to the pore structure in both microporous and mesoporous regimes and to its relative experimental simplicity of the pore structure, measurements of subcritical nitrogen adsorption at 77 K are the most used.

ACF's are highly porous materials with a fiber shape and a well-defined porous structure that can be prepared with a high adsorption capacity. The high adsorption capacity of ACF with other established adsorbent had been compared by many researchers.

Saha et al. [3,4] have compared the porous properties of silica gels, activated carbon and activated carbon fiber. Porous properties of three pitch types activated carbon fibers (ACFs), i.e. ACF (A-20), ACF (A-15) and ACF (A-10) from Unitika manufacturer company with three types of silica gels from Fuji Silysia manufacturer company (Type A<sup>++</sup>, Type 3A and Type RD) are determined from the nitrogen adsorption isotherms. Standard nitrogen gas adsorption/desorption measurements of the six types of adsorbents at liquid nitrogen temperature of 77.3 K were done. ACFs have large surface areas and their adsorption/desorption rates are rapid due to the existence of numerous micropores in the vicinity of the fiber surface. Figs. 1 and 2 show the experimental nitrogen adsorption/desorption isotherm data of three types of silica gel and three types of activated carbon fibers, respectively. As the adsorption experiments are run at a temperature lower than the critical capillary condensation temperature, the adsorption theory of infinite cylinder without any external surface predicts Type IV and Type I adsorption isotherm for silica gel curves (Fig. 1) and ACF curves (Fig. 2) respectively which are characterized by solid lines for adsorption and dotted line for desorption. Characteristics features of the Type IV isotherm are its hysteresis loop, which is associated with capillary condensation, and the limiting uptake over a range of high relative pressure,  $P/P_s$ . The Type I isotherm is given by microporous solids and is concave to the  $P/P_s$  axis, and the desorption amount approaches a limiting value as  $P/P_s$  to 1. The steep region at low  $P/P_s$  is due to the filling of very narrow pores, and the limiting uptake is dependent on the accessible micropore volume rather than on the internal surface area.

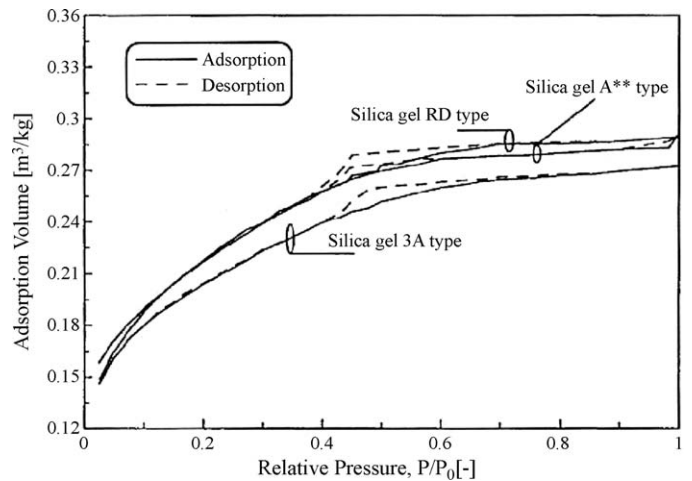


Fig. 1. The nitrogen adsorption/desorption isotherms of various silica gels. Saha et al. [3].

Fig. 1 shows that the RD type of silica gel has the highest adsorption capacity, followed by silica gel (Type A<sup>++</sup>). The breakthrough curves for all three silica gels show that the adsorption and desorption branches for each gel are not superimposed on one another when the value of  $P/P_s$  is greater than 0.4, which implies the presence of adsorption/desorption hysteresis. This indicates that the silica gel isotherms are not completely reversible. However, the breakthrough curves for all three ACFs are completely reversible in the whole range of  $P/P_s$ , i.e. they do not have any hysteresis. It is also evident from Fig. 2 that the adsorption volume, which is defined as cubic meter of refrigerant per kg of adsorbent, is highest for ACF (A-20) and lowest for ACF (A-10). Comparing Figs. 1 and 2 it is evident that the adsorption capacities of all three ACFs are higher than those of silica gels. It can also be noted that the pore filling  $P/P_s$  values for all three ACFs are equal and are as low as 0.4, while for silica gel the pore filling  $P/P_s$  value lies between 0.5 and 0.7.

Measurement of the nitrogen adsorption/desorption isotherm data for activated carbon, i.e. Maxsorb III at 77.4 K is presented clearly in Fig. 3. As the adsorption experiments are run at a temperature lower than the critical capillary condensation temperature, the adsorption theory of infinite cylinder without any external surface predicts Type I adsorption isotherm for Maxsorb III, which are characterized by solid lines for adsorption and dotted lines for desorption. The type I isotherm is given by microporous solids and is

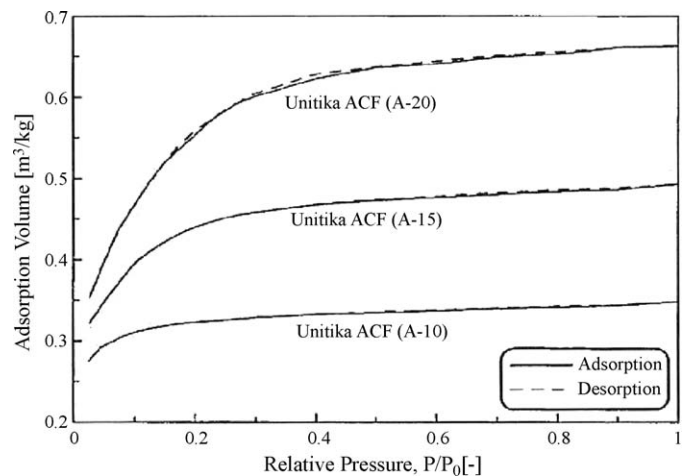


Fig. 2. The nitrogen adsorption/desorption isotherms of various carbon fibers. Saha et al. [3].

Download English Version:

<https://daneshyari.com/en/article/1751407>

Download Persian Version:

<https://daneshyari.com/article/1751407>

[Daneshyari.com](https://daneshyari.com)