International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal | www.ijtsrd.com
ISSN No: 2456 - 6470 | Volume - 2 | Issue – 6 | Sep – Oct 2018

# Analysis of Adsorption Time for Solar Adsorption Refrigeration System

**Soe Soe Nu**[1], **Dr. Mi Sandar Mon**[2]
[1]Lecturer, [2]Professor and Head
Yangon Technological University, Yangon, Myanmar

## ABSTRACT

The solar adsorption Refrigeration system is very useful in rural area without grid. The Adsorber/ desorber are the important role in this system. Among the adsorbent – refrigerant, the activated carbon and ethanol is applied. This paper focuses on the adsorption time of adsorber bed with constant thickness.

***Keyword:*** *Solar energy, Ethanol, Activated carbon, Solid Adsorption, adsorption time.*

## I. INTRODUCTION

The refrigeration system is important role in human life. The refrigerators are essential in the food preservation as well as storage of medicine and vaccine. There are two type of refrigerator, vapour compression refrigerators, use the electric power source and solid adsorption refrigeration systems, use the only heat source, such as solar energy and waste heat. Therefore, the adsorption refrigeration is purposed for remote area without electric grid. The possible adsorbent-refrigerant are activated carbon – methanol, olive waste – methanol, zeolite – ethanol and activated carbon – ethanol and etc. For this paper the activated carbon and ethanol are used as adsorbent and refrigerant.

## II. SYSTEM DESCRIPTION

1. The adsorption refrigeration system is operated at two different pressures like a vapour compression refrigeration system. In adsorption refrigeration system, the pressure is raised by heating it can be any heat source such as waste heat or solar energy.

   The principle of solid-adsorption Refrigeration system is described using claperyon diagram ( in P vs -1/T). Figure 1 shows the idealized process undergone by Activated Carbon and ethanol in achieving the refrigeration effect.
2. The cycle begins at a point (point 1at fig 1) where adsorption is low Temperature T1 and at pressure Pe . line 1-2 represents the heating of A.C along with ethanol. The collector is connected with the condenser and the progressive heating of the adsorbent from 2 to 3 causes some adsorbate (refrigerant) to be desorbed and its vapour to be condensed. When the adsorbent reaches its maximum temperate $T_3$, desorption stop. Then the liquid ethanol is transferred into the evaporator and absorbed the heat at evaporator and the refrigerant become vapour again.
3. The collector is closed and cooled. The decrease in temperature from 3 to 4 induces the decrease in pressure from Pc to Pe. Then the collector is connected with the evaporator. The adsorption and evaporation occur with the adsorbent is cooled from 4 to 1 during this cooling, the temperature of the adsorbent and to withdraw adsorption heat.

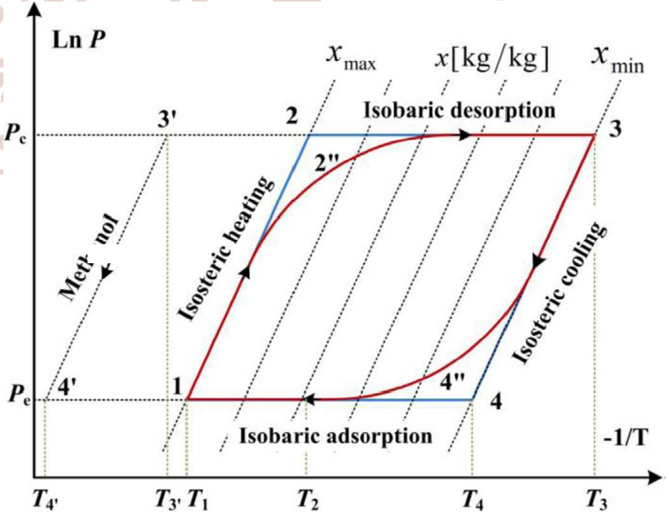

Figure1. The Claperyon Diagram of the adsorption refrigeration cycle

## III. ANALYSIS ON ADSORPTION AT ADSORBER BED

Mass concentration or mass density: The mass concentration of the component A within a multi component mixture is defined as mass of species A per unit volume of the mixture under consideration. It is denoted by $\rho_A$ and is expressed in $kg/m^3$.

Mass concentration $\rho_A$

$$= \frac{\text{Mass of component A}}{\text{Volume of mixture}} = \frac{m_A}{V}$$

Molar concentration: The molar concentration of the component A is defined as the number of moles of species A per unit volume of mixture. It is also called molar density and denoted by $C_A$ and expressed in $kg.mol/m^3$.

The molar concentration,

$$C_A = \frac{\text{No. of moles of component A}}{\text{Volume of mixture}} = \frac{n_A}{V}$$

Number of moles of component:

$$n_A = \frac{\text{Mass of component A}}{\text{Molecular weight of A}} = \frac{m_A}{\mathrm{M}_A}$$

Therefore, molar concentration,

$$C_A = \frac{\text{Mass of component A}}{\text{Volume of mixture} \times \mathrm{M}_A} = \frac{\rho_A}{\mathrm{M}_A}$$

where $\mathrm{M}_A$ = molecular weight of component A.

Mass fraction: The mass fraction $x_A$ is defined as the ratio of mass concentration of species A to the mass density ρ, of mixture,

$$x_A = \frac{\rho_A}{\rho}$$

Mole fraction. It is defined as the ratio of number of moles of component A to the total number of moles of mixture. It is denoted by $\gamma_A$ and expressed as:

$$\gamma_A = \frac{C_A}{C}$$

Partial pressure: It is defined as the pressure exerted by a single component in a mixture, when it exits alone in the system at the temperature and volume of the mixture. The total pressure of a mixture is the summation of partial pressures of all components in the mixture,

$$P = P_1 + P_2 + P_3 + \cdots + P_n$$

For a binary mixture of component A and B, the following summation rules may be applied.

$$\rho_A + \rho_B = \rho$$
$$C_A + C_B = C$$
$$x_A + x_B = 1$$
$$\gamma_A + \gamma_B = 1$$

$$\frac{x_A}{\mathrm{M}_A} + \frac{x_B}{\mathrm{M}_B} = \frac{1}{\mathrm{M}}$$

Where ρ, C, M are the quantities pertaining to the mixture

$$\rho_A = \frac{P_A}{\mathrm{RT}} = \frac{\mathrm{M}_A P_A}{\mathrm{R}_u \mathrm{T}}$$

$$\frac{m^\circ_A}{\mathrm{A}} = -\mathrm{D}_{AB} \frac{\mathrm{M}_A}{\mathrm{R}_u \mathrm{T}} \frac{dp_A}{dx}$$

$$\mathrm{D}_{AB} = 435.7 \frac{T^{\frac{3}{2}}}{P(\mathrm{V}_A^{\frac{1}{3}} + \mathrm{V}_B^{\frac{1}{3}})} \times \sqrt{\frac{1}{\mathrm{M}_A} + \frac{1}{\mathrm{M}_B}}$$

Where $\mathrm{D}_{AB}$ = diffusion coefficient, $cm^2/s$
T = absolute temperature, K
P = total pressure of system, $N/m^2$ or Pa
$\mathrm{V}_A$ = molecular volume of component A
$\mathrm{V}_B$ = molecular volume of component B
$\mathrm{M}_A$ = molecular weight of component A
$\mathrm{M}_B$ = molecular weight of component B

The one dimensional molar diffusion,

$$\mathrm{N}_A = \mathrm{D}_{AB} \frac{\mathrm{C}_{A1} - \mathrm{C}_{A2}}{\mathrm{L}}$$

## IV. DESIGN CONSIDERATION

The mass flow rate of refrigerant is constant and the pressure of evaporator and adsorber are same. The length of adsorber bed is divided into six sections. Moreover, the refrigerant at the entrance of absorber is absorbed immediately by the first section. The concentration at the adsorber bed is zero. In here, Subscript A represents refrigerant and B represents activated carbon. The evaporation time for one cycle is 10 min.

## V. THE DESIGN ASSUMPTION

This research is performed for 500 W of evaporator. The useful data and some assumption are shown in the following table.

Table1. Design Data

| **Evaporator load (W)** | **500** |
|---|---|
| Evaporator temperature (C) | 5 |
| Evaporator pressure (MPa) | 0.0021 |
| The mass flow rate of refrigerant (kg/sec) | 0.000531 |
| The mass of activated carbon (kg) | 3.8232 |
| Volume of activated carbon ($cm^3$) | 9558 |
| The thickness of adsorbent (cm) | 10 |
| The length of adsorbent (cm) | 30 |

## VI. RESULT AND DISCUSSION

The adsorber bed is divided into six sections. The calculation is performed only first section, the length of section is 5 cm. Therefore the length of first section is 5 cm. the following results are obtained, shown in Table 2.

Table2 Results of adsorbent bed.

| **Mass diffusion coefficient** | **$D_{AB}$ ($cm^2/s$)** | **2.1 $x10^{-4}$** |
|---|---|---|
| Rate of molar diffusion | $N_A$ kg-mole/s | 3.048 $x10^{-3}$ |
| Mass diffusion rate | $\dot{m}_A$ (kg/s) | 0.14 |
| Mass of refrigerant for one cycle | m (kg) | 0.3186 |
| Adsorption time for one cycle | t (s) | 2.3 |

## VII. CONCLUSION

It is found that the first section of absorber can absorb the refrigerant easily because the rate of mass of refrigerant to be absorbed is greater than the flow rate of refrigerant from evaporator. The calculation will be ahead for other sections. The thickness of adsorber 10 cm is suitable for this system. In this system the flow is one dimensional, downward. The evaporation time for one cycle is 10 min and the adsorbtion time is 2.3 second for one cycle. In conclusion, it is satisfied that the adsorption time is faster than evaporation time.

The forward dimensional should be considered. Moreover, the two and three dimensional also should be considered.

## ACKNOWLEDGMENT

The author would like to thank to my supervisor, Dr. Mi Sandar Mon, Professor and Head of Mechanical Engineering Department, Yangon Technological University who is a special guidance for me.

The special thanks go to DEEM (Development of Energy Engineering Mekong) project.

## REFERENCES

1. K. Sumathy and Li Zhongfu ,“ Experimental with solar-powered adsorption ice-maker,” Department of Mechanical Engineering, University of Hong Kong , Hong Kong, 1999.
2. Nadal H. Abu-Hamdeh, Khaled A. Alnefaie, Khalid H. Almitani, “ Design and performance characteristic of solar adsorption refrigeration system using parabolic trough collector: Experimental and statistical optimization technique,”
3. A. M. Abu-Zour, S. B. Riffat, “Solar-Driven Air-conditioning Cycle: A Review,” The Journal of Engineering Research vol.4, no.1, 2007, pp. 48-63.
4. V. Baiju and C. Muraleedharan, “Performance of Solar Adsorption Refrigeration system by Ann,” ISRN Thermodynamics, vol 2012, Article ID 102376,
5. A. V. Kanade, A. V. Kulkarni, D. A. Deshmukh, “solar power Adsorption Ice Maker System,” International Research Journal of Engineering and Technology(IRJET).
6. Mashesh M. Rathore, “Engineering Heat and Mass Transfer” Third Edition, (2016), University Science Press.