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## Effect of Evaporator and Condenser in the Analysis of Adsorption Chiller

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### Abstract

In many studies, numerical analysis in adsorption chillers has focused on analyzing adsorption bed, which is the most important part, and evaporator and condenser are ideally assumed. It is doubtful whether this analysis properly evaluated the performance of the adsorption chillers. Although there have been some studies involving evaporators and condensers, it is questionable whether this is a quantitative result because the adsorption bed which has the greatest effect on performance, is analyzed by a lumped parameter model (LPM). In this study, an adsorption chiller including an evaporator and a condenser is analyzed and the results are compared with the result of a previous study that assumes an ideal evaporator and a condenser. As a result of analyzing in terms of coefficient of performance and specific cooling power, the analysis including the evaporator and condenser showed 16.12% and 24.64% overestimation compared. Also, LPM analysis including evaporator and condenser showed that COP and SCP were 22.82% and 11.28% larger than our model, respectively

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*Keywords:* adsorption chiller; numerical analysis, evaporator, condenser

### 1. introduction

Because of global warming and economic development, cooling demand has rapidly increased. There are many kinds of refrigerator types. The vapor compression refrigerator has been most commonly used, however, it suffers from a negative impact on the environment and an excessive electric power requirement. Therefore, many researchers have focused on developments of eco-friendly refrigeration systems, and heat driven refrigerators have been highly attracted such as absorption, desiccant, and adsorption cooling system.

The adsorption refrigerator operates reversible adsorption and desorption processes, in a cycle of preheating, heating, pre-cooling, and cooling. The size of adsorption chiller is large and cycle time is too long. For this reason, the experimental study is highly time-consuming and expensive, a numerical study has been widely used, to understand the process in adsorption refrigerator.

Niazmand et al [1] focused on the issue of bed geometry and found the difference in performance caused by heat and mass transfer ability. The performance of refrigerator was improved by changing fin height and fin space. Mahdavihah et al. [2] investigated the pressure distribution of the bed in isosteric phase to understand the complex mechanism of heat and mass transfer in the square finned adsorption bed. They found the optimized shape which evenly distributed the heat energy.

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From the literature survey, even though adsorption bed is one of the crucial components in adsorption refrigerator, the research target was mainly confined to the adsorption bed. The effect of its integration with evaporator and condenser has not been closely examined till now. A few works have focused on this issue. Khan et al. [3] numerically analyzed reheat-2stage adsorption refrigerator using LPM (lumped parameter model). They performed a case study with the parameters of silica gel mass and its surface area. Zhang et al. [4] analyzed an adsorption refrigerator driven by solar power with Simulink. They found the cooling capacity by assuming day-time solar radiation and showed that the COP was different depending on the initial temperature. Ng et al. [5] researched a desalination cycle driven by waste heat and suggested an optimal condition.

A few works have focused on the analysis including not only adsorption bed but also additionally including evaporator and condenser. Therefore, in this study, we focus on refined CFD simulation for adsorption bed with evaporator and condenser which is the more realistic model.

## 2. Numerical method

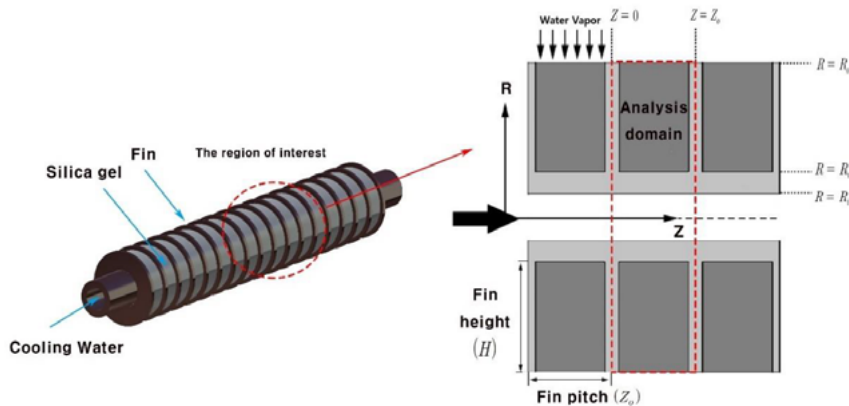


Fig. 1. numerical model of the circular fin – tube

Fig. 1 describe numerical model of fin-tube type adsorption chiller. The numerical model includes the following assumptions.

- (1) 2-D axisymmetric model is assumed.
- (2) No heat loss through the wall and effect of radiation is negligible.
- (3) Vapor is an ideal gas and silica gel is liquid phase.
- (4) Particle has uniform size and same porosity.

The detailed properties such as isotherm of adsorbent, bed analysis model, and numerical model verification were described in our recent studies (Hong et al. [6]), so it is not discussed further.

Another model, which contains evaporator and condenser, use same equation with previous model for analysis of adsorption bed. We use equations for evaporator and condenser which can be found in some existing paper (Khan et al. [3]).

## 3. Result

Fig. 2 describes the Clapyron diagram of an adsorption refrigerator that reaches quasi-equilibrium state. As indicated by the dotted line, the idealized model does not follow the actual pressure, but rather has constant saturation pressure corresponding 15°C and 30°C, which are evaporator and condenser temperature. On the other hand, a realistic model indicated by the solid line follows the pressure corresponded with actual evaporation or condensation temperature. The existence of the pressure gradient finally affects the adsorption/desorption isotherm. Fig. 3 shows difference in water uptake amount.

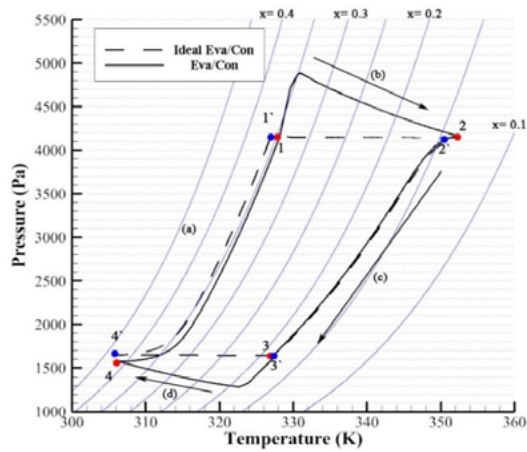


Fig. 2. P-T diagram in adsorption bed of two models

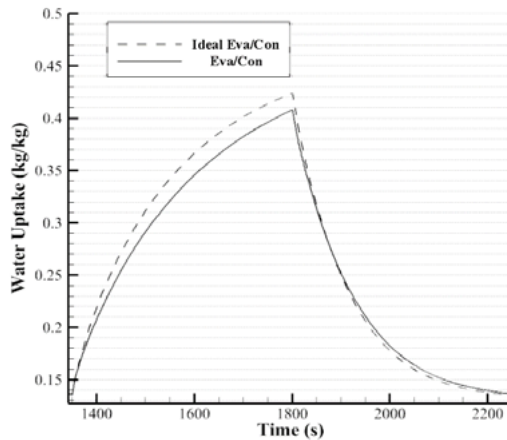


Fig. 3. Difference in water uptake between two model

For this reason, when evaporator and condenser was ideally designed, COP was overvalued up to 16.12%. Furthermore, SCP was overvalued up to 24.64%. So, it is better to use the analysis which cover evaporator and condenser to avoid distorting the result.

### Acknowledgements

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