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固体吸着剤による CO_2 除去システムの吸脱着プロセスの最適手法の検討

A Study on Optimization Methods in Adsorption/Desorption Process of a Carbon Dioxide Removal System Using Solid Adsorbent

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1. Introduction

In spacecraft such as the ISS (International Space Station), control of the environment, including water and air, is essential to maintain human life. A human emits 500 L of carbon dioxide per day[1)]. In enclosed spaces, such as inside a spacecraft, carbon dioxide concentrations will increase and affect the human body if carbon dioxide is not removed. Therefore, it is necessary to maintain appropriate carbon dioxide concentrations by removing carbon dioxide. Carbon dioxide removal equipment on the ISS mainly uses CDRA (Carbon Dioxide Removal Assembly) in US module and Vozdukh in Russian module. These carbon dioxide removal systems use adsorbent to remove.

A typical system schematic of a four-bed temperature and pressure swing carbon dioxide removal system is shown in Figure.1. Two are desiccant bed and the other two are carbon dioxide sorbent bed. Solid adsorbents such as zeolites are used for carbon dioxide adsorption, but they also adsorb water. Therefore, silica gel in the desiccant bed first adsorbs the water in the air, and then adsorbs carbon dioxide. Adsorbent adsorption and desorption are performed using temperature differences because the amount of adsorption varies depending on temperature and pressure. Desiccant bed and carbon dioxide sorbent bed perform adsorption in one and desorption cyclically in the other, enabling continuous treatment. During adsorption, the adsorption volume is increased at a low temperature, and during desorption, the adsorbed components are heated by a heater to a high temperature for desorption. Need to set appropriate parameters such as temperature, cycle time, etc. for efficient adsorption/desorption.

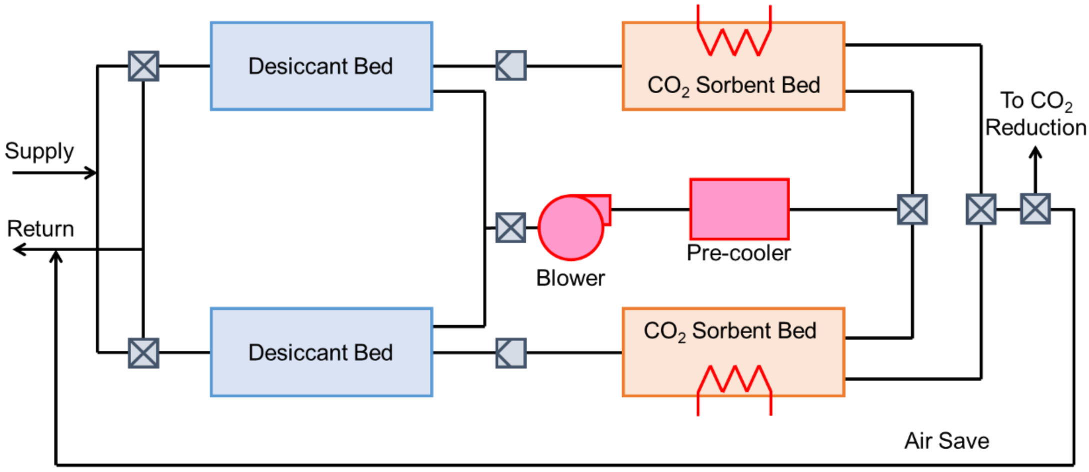

Figure 1. Schematic diagram of carbon dioxide adsorption/desorption equipment

This study aims to optimize a carbon dioxide removal system using solid adsorbents. carbon dioxide removal systems require the proper adjustment of various parameters such as temperature and pressure, and these values are obtained from experience. Therefore, the final purpose is to model, derive optimal values, and introduce them into the CO2 removal system. This paper describes an analytical model of silica gel for a desiccant bed.

2. Analysis Model

A schematic diagram of the system analyzed in this study is shown in Figure 2. The respective values in Figure 2 are shown in Table 1. These are analyzed for the vacuum case and the air case with convection. The same is also done for the case where copper of the same diameter is introduced. The depth is not considered in this case.

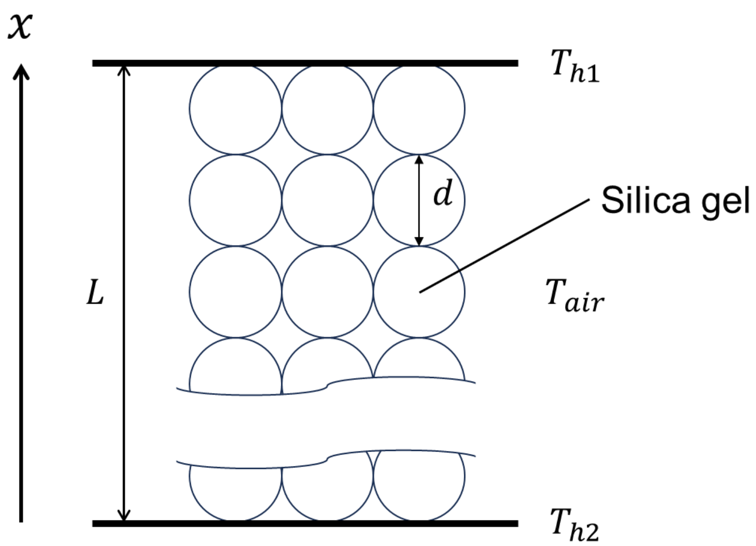

Figure 2. Schematic diagram of silica gel adsorption bed

Table 1. Various values for silica gel adsorption bed

L	10 [mm]
d	0.5 [mm]
T_{h1}, T_{h2}	400 [K]
T_{air}	300 [K]

The 1-D heat equation and Fourier's law equations are shown in equations (1) and (2).

$$c\rho\frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(\lambda\frac{\partial T}{\partial x}\right) \tag{1}$$

$$dQ = -\lambda\frac{\partial T}{\partial n}dA \tag{2}$$

Where c is specific heat, ρ is density, λ is thermal conductivity, T is temperature, $\frac{\partial T}{\partial n}$ is temperature gradient, Q is amount of heat and A is area. These equations are used to analyze heat transfer. In addition, since thermal resistance such as thermal contact resistance must be taken into account, the thermal conductivity is given by equation (3)[2)].

$$\lambda = \frac{L}{A(R_{bed} + TCR)} \tag{3}$$

Where R_{bed} is thermal resistance of packed bed and TCR is thermal contact resistance.

In the presentation, we will report on the analysis of temperature distribution for this analytical model.

References

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