Comparison of Odor Transfer Characteristics of Total Heat Exchangers Between Ion Exchange Resin and Porous Adsorbent as Desiccant

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Honeycomb Rotor
Total Heat Exchanger

- A total heat exchanger is an energy saving device used in the ventilation and air conditioning.
- It exchanges and recovers both sensible heat (temperature) and latent heat (humidity) simultaneously.
- In a typical example, 28% of the air conditioning load is saved among the total load of 75.2Mcal/m²
**Honeycomb Structure**

Both side of aluminum sheet is coated with desiccant particles to give an ability of the latent heat (humidity) exchange.

**Sensible, Latent and Total Heats Recovered**

Presentation on a humidity chart (Cooling case)
Adsorption Isotherm of Water Vapor

Ion exchange resin is as good desiccant as porous adsorbents

Heat Exchange Efficiency

A honeycomb rotor of ion exchange resin as desiccant works with exchange efficiency as high as 80% as well as a silica gel rotor.
Release of Offensive Odor

1) Various odor substances and solvent vapors are emitted from construction and interior materials of a new building. Such odor substances are adsorbed and accumulated in adsorbent such as silica gel when the return air from buildings is exhausted through total heat exchangers.

2) In early spring or in the rainy season when the humidity increases rapidly, odor substances are desorbed due to an increased amount adsorbed of water vapor on adsorbert. In other words, accumulated odor substances are desorbed into the room by so called the replacement adsorption of water.

3) When adsorbent of a total heat exchanger is adsorbable to odor substances as well as water vapor, odor released from total heat exchangers is circulated again in the room by transferring from the return air to the supply air. Odor substance cannot be exhausted outdoors endlessly, resulting in customers’ complaints.

Cause of Odor Transfer

- Desiccant sometimes adsorbs and accumulates offensive odors like VOC emitted from building materials.
- The odor substances are desorbed and released from desiccant materials due to replacement adsorption when the relative humidity rapidly increases.
- Odor cannot be discharged out of the room because it is exchanged as well as latent heat (humidity).
Odor Transfer Test

Test Rotor: 950 mm dia.

Transfer Ratio
\[ F = \frac{C_{SA} - C_{OA}}{C_{RA} - C_{OA}} \]

Specific Transfer Rate
\[ R = \frac{(C_{SA} - C_{OA})}{V_t} \]

Transfer Ratio F (1)
Water Vapor and IPA

Transfer Ratio \[ F = \frac{C_{SA} - C_{OA}}{C_{RA} - C_{OA}} \]

- The ion exchange resin rotor gives the highest transfer ratio for water vapor as well as silica gel.

- The ion exchange resin rotor rejects the odor transfer of isopropyl alcohol (IPA) completely.
**Transfer Ratio F (2)**

**Ammonium and Toluene**

Transfer Ratio \( F = \frac{C_{SA} - C_{OA}}{C_{RA} - C_{OA}} \)

- **Ammonium** \( C_{RA} = 0.018 \text{g/m}^3 \)
  - Ion ex. resin
  - Zeolite 3A
  - Alumina
  - Silica gel

- **Toluene** \( C_{RA} = 0.20 \text{g/m}^3 \)
  - Ion ex.
  - Zeolite 3A
  - Alumina
  - Silica gel

- The ion exchange resin rotor has the lowest transfer ratio for ammonium.
- The ion exchange resin rotor rejects the odor transfer of toluene completely.

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**Specific Transfer Rate R (1)**

**Water Vapor and IPA**

Specific Transfer Rate \( R = (C_{SA} - C_{OA})V_t \)

- **Water Vapor**
  - Ion ex. resin
  - Zeolite 3A
  - Alumina
  - Silica gel

- **IPA** \( C_{RA} = 0.13 \text{g/m}^3 \)
  - Ion ex. resin
  - Zeolite 3A
  - Alumina
  - Silica gel

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6
**Specific Transfer Rate R (2)**

Ammonium and Toluene

Specific Transfer Rate \( R = (C_{SA} - C_{CM})Vt_c \)

- **Ammonium**
  - \( C_{RA} = 0.016 \text{g/m}^2 \text{rev.} \)
  - **Transfer Rate R [g/(m}^2 \text{.rev.}]**

- **Toluene**
  - \( C_{RT} = 0.20 \text{g/m}^3 \)
  - **Transfer Rate R [g/(m}^2 \text{.rev.}]**

- **Face Velocity V[m/s]**

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**Odor Adsorption on Porous Adsorbent**

- Porous adsorbents adsorb odor substances together with water vapor by capillary force.
- Odor substances are desorbed by replacement adsorption in a rapid increase of humidity.

- **Water molecule**
- **Odor molecule**
Odor Adsorption on Silanol Group

- Silanol group has a strong adsorbing ability for water vapor and adsorbs odor as well.

\[
\begin{align*}
&\text{Si-O-H} \cdots \text{O} \\
&\text{H} \\
&\text{Si-O-H} \cdots \text{N} \cdots \text{H} \\
&\text{NH}_3, \text{Amines} \\
&\text{Si-O-H} \cdots \text{S} \cdots \text{H} \\
&\text{H}_2\text{S}, \text{Mercaptan, Sulfur compounds} \\
&\text{Si-O-H} \cdots \text{O} \\
&\text{Alcohol, Ether, Carbonyl, etc.}
\end{align*}
\]

Structural Model of Ion Exchange Resin

- The shrinking force due to crosslinkage and the swelling force due to hydration and osmotic pressure are balanced inside the resin.
- Even a water soluble odor substance is difficult to be solved into water inside resin due to thus high interior pressure.

\[
\begin{align*}
&\text{Di-vinyl benzene} \\
&\text{Free water} \\
&\text{Counter ion} \\
&\text{Fixed ion} \\
&\text{Styrene substrate} \\
&\text{Di-vinyl benzene linkage} \\
&\text{Styrene substrate} \\
&\text{Hydrated Water} \\
&\text{By Osmosis} \\
&\text{Free Water}
\end{align*}
\]
Swelling and Osmotic Pressure in Ion Exchange Resin

Summary

- Total (sensible and latent) heat exchangers have been widespread as an energy saving appliance.
- One of customers' complaints is the odor transfer happening in an early rainy season. It is caused by adsorption of odor substances in the adsorption step and accelerated desorption due to replacement adsorption of water in case of porous adsorbents.
- We have developed a honeycomb rotor by use of non-porous ion exchange resin, which has high desiccant ability but rejects odor substances.
- Seibu Giken Co., Ltd has commercialized a new type of the total heat exchanger with a trade name of Hi-Panex Ion
- Hi-Panex Ion was awarded the 2004 technology prize by the Japan Society of Adsorption.
**SG Products**

Ion Adsorption Type
Total Heat Exchanger **HI-PANEX ION**

- Photographs

**Total heat exchange rotor**

Material: Aluminum
Φ 3900 × 200mm

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**SG Company Profile**

**Global Communication**

We export our products to more than 30 overseas countries.

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Seibu Giken DST AB
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- 21 European countries
- U.S.A.
- Korea
- China
- Taiwan
- Australia
- Canada
- Singapore
- Thailand
- Malaysia
- India
- Vietnam
- Pakistan
- Others