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NEW ADSORPTIVE TOTAL HEAT EXCHANGERS USING ION EXCHANGE RESIN

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ABSTRACT

A new type of total heat exchanger has been developed to recover both sensible heat (temperature) and latent heat (humidity) lost in ventilation of a building. The honeycomb rotor covered with fine powder of desiccative ion exchange resin can eliminate the troubles of odor transfer without any sacrifice of heat exchange efficiency. The new type rotor has been in the domestic market in favor in Japan in place of the conventional type using silica gel since July 1998.

INTRODUCTION

A total heat exchanger is a device which exchanges sensible heat (temperature) and latent heat (humidity) at the same time. During most Asian summers, for example, the outside air is hot and humid but inside residents are seeking cool and dry air. The total heat exchanger absorbs incoming moisture and transfers it to the exhausting air. The coolness of the exhausting air is captured and transferred to the hot incoming air. The situation is vice versa in winter. The total heat exchanger can recover 70-80% of energy lost in ventilation of a building. Its excellent energy-saving property has been acknowledged since a basic patent was invented in Sweden in 1950's. But in wide use of total heat exchangers in recent years, arising is a problem that odor is transferred or an offensive smell is generated in total heat exchangers. Even though the probability is as low as less than 1%, once it breaks out, it can be a serious problem due to sharp uncomfortableness. In the present study, this problem of odor transfer was solved by combining ion exchange resin with a total heat exchanger rotor.

MANUFACTURE OF TOTAL HEAT EXCHANGER ROTOR

Several methods are available to give latent heat exchanging function to a honeycomb rotor; impregnating porous honeycomb with desiccative salt; forming a desiccative layer on the surface of aluminum honeycomb by corrosion in a chemical process; making adsorbent such as silica gel adhere to the inside of honeycomb. In the present study, fine particles of ion exchange resin were sprayed and adhered rigidly to aluminum sheet coated with adhesive agent. Finally it was treated with anti-bacterial and anti-mold coating. The aluminum sheet was corrugated and made into a honeycomb rotor. (Fig.1)

Ion exchange resin selected was one with desiccative characteristics intermediate between silica gel A type and silica gel B type and with adsorbed amount comparable with others as shown in Fig.2. Amount of odor adsorbed was tested for isopropyl alcohol: Ion exchange resin adsorbs as little as 3.4g/kg at saturated vapor pressure, which is 5 times smaller than silica gel. Chemical stability, thermal stability, cost and safety were considered in selection of resin.

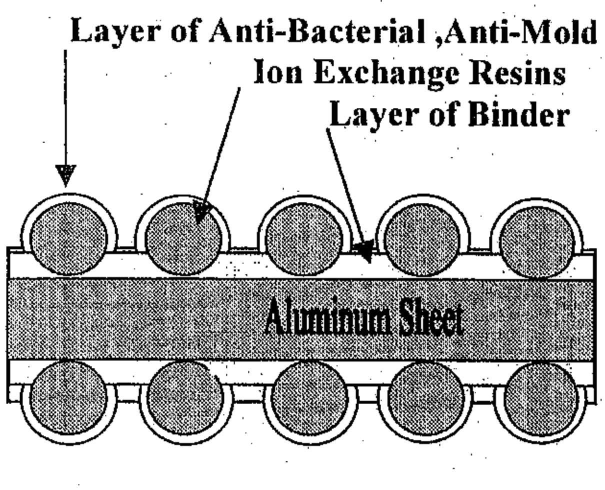

Fig.1 Sectional View of Honeycomb Sheet

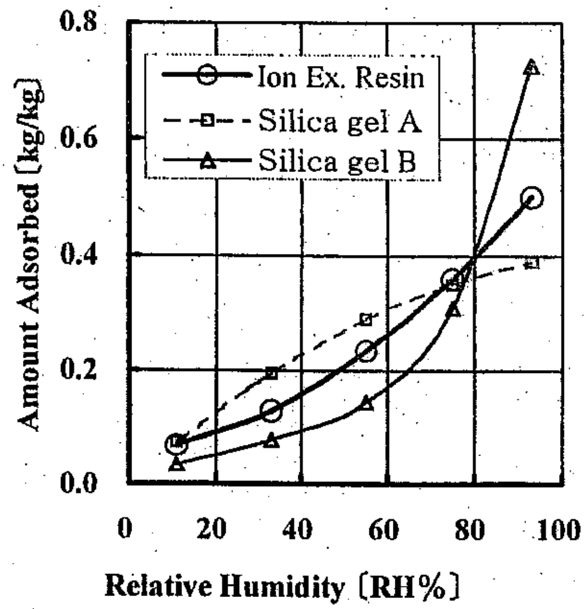

Fig.2 Isotherms of Water Vapor Adsorption

HEAT EXCHANGE PERFORMANCE AND ODOR PRVENTION

Performances of total heat exchange and odor transfer prevention were tested in a wind tunnel as shown in Fig. 3. Exchange efficiency of total heat on enthalpy basis as well as pressure loss Δp is shown as a function of the face velocity in Fig. 4 and compared with that of silica gel type exchanger. The present resin type heat exchanger gives the same efficiency as the conventional silica type, as shown in the figure.

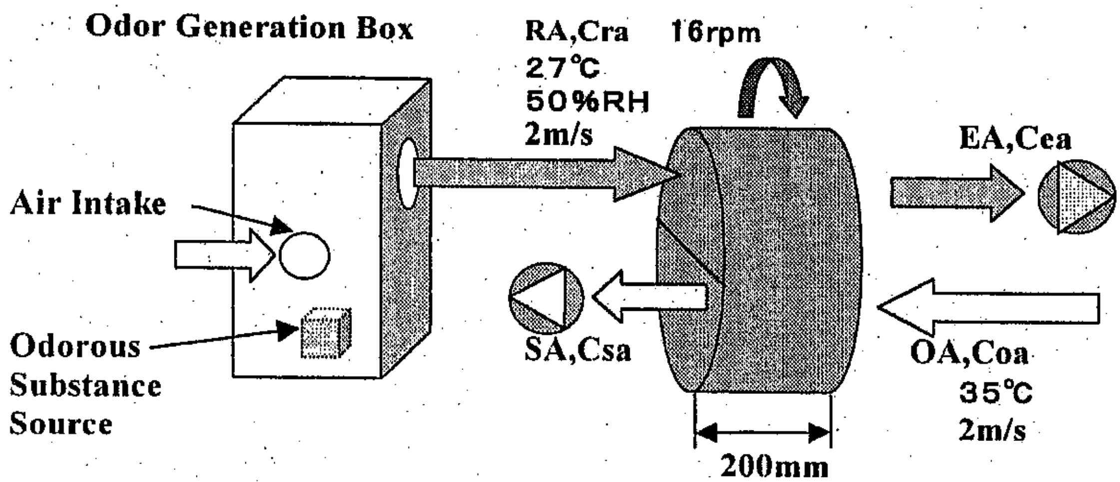

Fig.3 Figure of Test Device

For odor transfer test various odors were generated from the return air (RA) side and odor concentrations Coa, Csa and Cra were measured in the outer air (OA), the supply air (SA) and the return air (RA). Odor transfer ratio was calculated by the following formula:

$$\text{Odor transfer ratio} = (Csa - Coa)/(Cra - Coa) \quad (1)$$

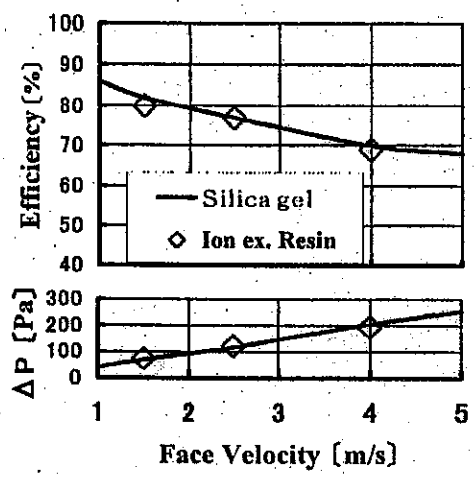

Fig.4 Exchange Efficiency and Pressure Loss

The test result of odor transfer is shown in Fig.5 as a function of relative humidity of room air (RA). Odor transfer ratio is remarkably low in the new type rotor using ion exchange resin compared with the conventional silica gel type. In the conventional type, odor transfer ratio tends to increase when relative humidity of the OA(outer air) side increases while the influence of relative humidity is little in the new type using ion exchanging resin. Thus, the resin type rotor can eliminate the trouble of odor transfer which most often has happened at higher humidity in the rainy season.

The transfer ratio of ammonia for the news resin type could not be reduced to high extent compared with the other odors, although it can be kept less than half of that for the conventional silica type. This is considered because ammonia has extremely high affinity for water and any surface. For example, we have confirmed that about 10% transfer of ammonia was generated even when a rotor was made of aluminum metal with no desiccative property.

Solid adsorbent such as silica gel is considered to be able to adsorb odor because silanol group with strong desiccative property adsorbs odor as well as water vapor and odor is dissolved in condensed water due to capillary adsorption, as shown schematically in Fig.6.

On the contrary, ion exchange resin adsorbs little odor by the reason as follows. Ion exchange resin has desiccative property similar to silica gel as shown in Fig.2 by hydration of ion and osmosis, but does not have pores in dry condition unlike solid adsorbents such as silica gel. Therefor there is no room for odor molecules within the hydration radius of ion and also in humid condition, osmosis prevents odor molecules form going inside the resin.

This new total heat exchanger using ion exchange resin has a total heat exchanging efficiency favorably compared with the conventional one using silica gel and has less odor transfer than any of former type. This product has been in the domestic market in Japan in favor since July, 1998.

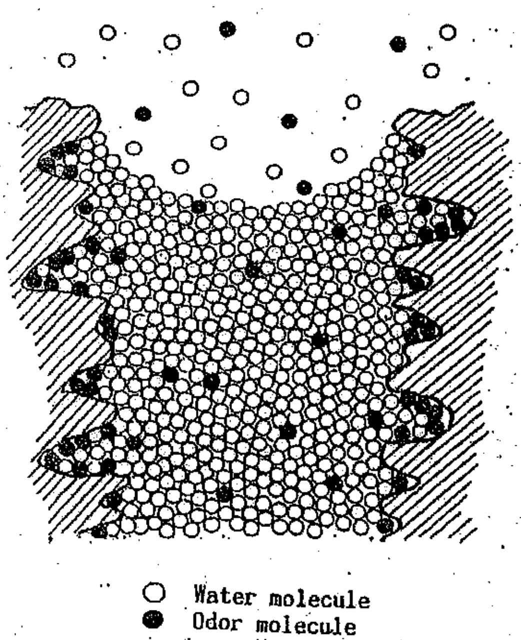

Fig.6 Capillary Condensation of Water Vapor in Mesopore

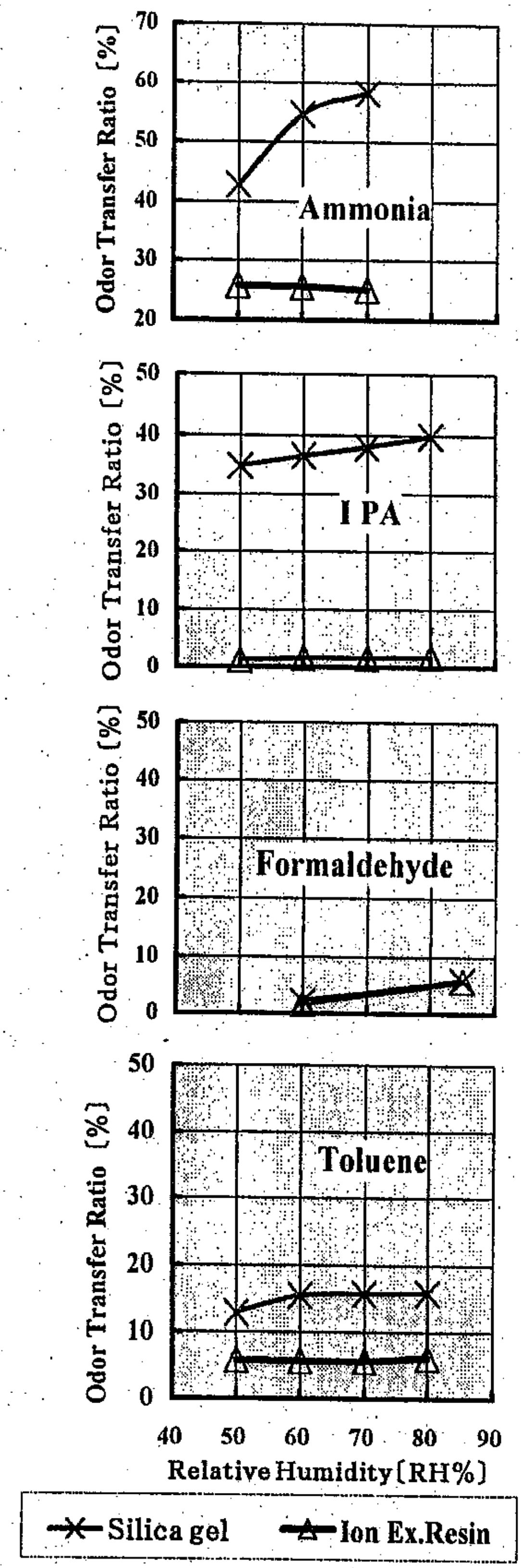

Fig.5 Transfer Ratio of Odorus Substance