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Experimental investigations on desiccant wheels

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ABSTRACT

Experimental investigations on several commercially available and newly fabricated rotors are conducted in two different laboratories to evaluate performance trends. Experimental uncertainties are analysed and the parameters determining the rotor performance are investigated. It is found that the optimal rotation speed is lower for lithium chloride or compound rotors than for silica gel rotors. Higher regeneration air temperatures lead to higher dehumidification potentials at almost equal dehumidification efficiencies, but with increasing regeneration specific heat input and enthalpy changes of the process air. The influence of the regeneration air humidity was also notable and low relative humidities increase the dehumidification potential. Finally, the measurements show that rising water content in the ambient air causes the dehumidification capacity to rise, while the dehumidification efficiency is not much affected and both specific regeneration heat input and latent heat change of the process air decrease. For desiccant cooling applications in humid climates this is a positive trend.

1. Introduction to desiccant wheel characterisation

Desiccative and Evaporative Cooling (DEC) systems are based on the principle of adiabatic evaporative cooling. The extent to which the supply air can be cooled through humidification is usually limited by the maximally allowed water content of the supply air. Especially in hot and humid climates, the ambient air contains so much water that very high dehumidification rates are required. For a continuous dehumidification of the process air the water adsorbed on the desiccant material has to be removed, which is done by allowing hot air to flow through the desiccant material (regeneration).

A range of materials are used for today's desiccant rotor constructions. The synthetically-produced silica gel is a fine pored solid silicic acid which consists of 99% silicon dioxide. It can adsorb up to 40% of its dry weight in water when in equilibrium with air at saturation. Silica gel can withstand temperatures up to 400 °C and is a solid, insoluble desiccant. No special precautions are required when it is exposed to air at 100% relative humidity. It is also possible to wash a wheel in water if dust or other particulate block the air passageways. Silica gel does not undergo any chemical or physical change during the adsorption process. It is inert, non-toxic, stable and resistant to most chemicals [1] [2], and [3].

Lithium chloride can attract and hold over ten times its weight in water and is one of the most hygroscopic compounds that exist. Its ability to attract and hold water is due to the absorption of water through a chemical reaction. As lithium chloride is water soluble, precautions are required to protect the wheel from high relative humidity. Lithium chloride prevents the growth of bacteria on the wheel surface. It can also significantly reduce the number of organisms which may be carried in the air stream. Test results show that there is typically a 25%–50% reduction in the bacteria content of the air as it passes through the wheel. Lithium chloride is unaffected by most air stream pollutants, and resistant to many contaminants such as petroleum vapour, solvents, etc.

A molecular sieve or synthetic zeolite is a crystalline material of aluminium silicate which is capable of separating molecules of different sizes by sorption. Therefore, small molecules, such as water molecules for example, are adsorbed while large molecules pass through the wheel. Molecular sieve materials are suitable for special applications that call for the dehumidification of air to a very low level of humidity and extremely low dew points of about −40 °C to −60 °C. For the same reason, the molecular sieve has a better sorption capacity at higher temperatures than other sorbents.

Composite desiccant materials have been used to increase the dehumidification capacity [4]. Combining different host matrices such as mesoporous or microporous silica gels, alumina, porous carbons or polymers with inorganic salts such as CaCl2, LiBr, MgCl2 or LiCl change the sorbent properties in a wide range. A compound

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