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Solar powered air conditioning system using rotary honeycomb desiccant wheel

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Abstract

A solar powered air conditioning system using liquid desiccant is proposed. A solar air heater containing a porous material is used for regeneration purpose in the proposed system. The honeycomb desiccant rotary wheel is constructed from iron wire and clothes layer impregnated with calcium chloride solution, in honeycomb form, is utilized for the regeneration and absorption processes. The effect of airflow rate and solar radiation intensity on the system regeneration and absorption processes are studied. The obtained results show that the system is highly effective in the regeneration process. An empirical equation to calculate the removed moisture as a function of air flow rate at solar noon is obtained. Also empirical equation for wheel effectiveness as a function of air flow rate for regeneration and absorption process was obtained.
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Keywords: Air conditioning system; Liquid desiccant; Desiccant rotary wheel; Absorption and regeneration

1. Introduction

Desiccants are chemicals with great affinity to moisture. Therefore, desiccants can be used as supplement to conventional vapor compression systems in order to remove the latent heat load. Desiccants are efficient in handling latent heat load (i.e., reducing the humidity), but the evaporator in the vapor compression system is efficient in handling

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Nomenclature

A	collector area, m^2
C_p	specific heat capacity kJ/kg °C
G	solar radiation intensity, W/m^2
ΔH	specific cooling capacity, kJ/kg
h_1	enthalpy of air at ambient condition, kJ/kg
h_2	enthalpy of air after absorption process, kJ/kg
M_{w_1}	moisture removal capacity of supply air, g/h
M_{w_2}	moisture added to air by regeneration process, g/h
m_1	air flow rate in wheel absorption part, kg/h
m_2	air flow rate in wheel regeneration part, kg/h
Q_C	the cooling capacity of desiccant assisted air condition, W
w_1	specific humidity of air at ambient condition, g/kg
w_2	specific humidity of air after absorption process, g/kg
w_4	specific humidity of air after regeneration process, g/kg
S_{COP}	system coefficient of performance
T_{out}	collector exit temperature, °C
T_{in}	collector inlet temperature, °C
T_{coll}	collector temperature, °C
$\tau\alpha$	tansmissivity absorptivity product
F	collector efficiency factor
U_L	overall heat loss coefficient, W/m^2 °C
ε_w	the performance of the desiccant wheel's effectiveness
η	the thermal efficiency of flat-plate collector
ψ_{ab}	wheel effectiveness in absorption process
ψ_{reg}	wheel effectiveness in regeneration process

the sensible cooling loads (i.e., lowering the air temperature). Davanagere [1] summarized the advantages of using desiccant in the following points:

(1) It consumes very little electrical energy, and for regeneration process it allows the use of solar energy and waste energy.
(2) It is efficient when latent heat load is larger than the sensible load.
(3) It is a clean technology, which can be used to condition the internal environment of buildings and operates without the use of harmful refrigerants.
(4) The achieved control of humidity is better than that when using vapor compression systems
(5) In some cases the cost of energy to regenerate the desiccant is less than that when compared with the cost of energy to dehumidify the air by cooling it below its dew point.
(6) Improvement in indoor air quality is more likely due to the normally high ventilation.
(7) It has the capability of removing airborne pollutants.

In hot and humid climates, the humidity puts an extra load on the electric vapor-compression air conditioning system. Liquid and solid desiccants can reduce the moisture

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