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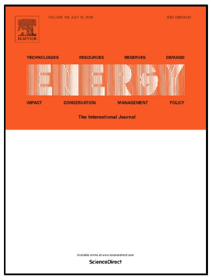

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Abstract

This work presents theoretical study of a standalone outdoor liquid desiccant air conditioning (LDAC) system assisted by solar energy. The liquid desiccant dehumidification cycle was integrated with a double indirect evaporative air cooler and a regenerative air heat recovery. The double indirect evaporative air cooler was used to recover heat from the return air, while air-air heat exchanger was used to recover heat from air leaving the regenerator. A water-in-glass evacuated tube solar collector was used to supply the system with solar heat. The remaining required heat is provided by natural gas fired boiler. The system was simulated by transient model under thermal energy storage, thermochemical energy storage and combined thermal and thermochemical energy storage modes.

The theoretical results show that the mean daily thermal coefficient of performance (TCOP) is a strong function of the difference between absolute humidity ratio of outdoor air and saturated air. Results also show that, each tube of solar collector can deliver 30-Watt to operate the LDAC system under thermal energy storage mode for 16 hours daily. While in the LDAC system under thermochemical energy storage mode, each tube would deliver 38.5-Watt for 16 hours operation.

It has been found that, to rise the solar fraction from 90% to 100% in the thermal energy storage mode, the required size of tubes array will be increased by 20%. Also, an analysis was carried out on the TCOP and required storage volume of the different energy storage modes. It shows that the combined energy storage method is the most energy efficient method.

Finally, life cycle cost analysis (LCCA) was carried out for the LDAC system using various types of energy storage modes. The comparison indicated that 90% solar fraction LDAC system is the most economic system related to unit prices of solar collector and gas prices in Egypt. The total annual cost for the 90% solar assisted LDAC system is found to be lower than that of a vapor compression cycle (VCC) by about 50.5 %. At the second order, the thermal energy storage mode by 49%. On the other side, the thermochemical energy storage mode is the least cost saving energy storage mode.

Nomenclature

A	Area, m^2
c_p	Specific heat at constant pressure, J/kg K
g	Gravitational constant, 9.81 m/s^2
hs	Specific enthalpy, J/kg
H	Height, m
h	Heat transfer coefficient, W/m^2. K
h_{fg}	Latent enthalpy of vaporization, J/kg
k	Mass transfer coefficient, kg/m^2. s
t	Time, s
T	Temperature, ^oC
u	Internal energy, J/kg
U	Overall heat transfer coefficient, W/m^2. K
Q	Volume flow rate, m^3/s
v	Volume, m^3
W	Width, m
$\dot{m}$	Mass flow rate, kg/s
P	Motor power, W
ΔP	Pressure drop, kPa
S. F	Solar fraction
Greek letters	
t_{Lf}	Liquid film thickness, m
ε	Heat exchanger effectiveness
υ	Velocity, m/s
η	Efficiency
ω	Humidity ratio, kg water/kg dry air
ρ	Density, kg/m^3
λ	Thermal conductivity, W/m. K
Subscripts	
G	Dry air
*	Initial
pump	Pump
fan	Fan
st	Stored
v	Water Vapor
w	Liquid water
p	Primary
S	secondary
NG	Natural gas
hw	Hot water
Deh	Dehumidifier
Reg	Regenerator
in	Inlet
out	Outlet
Abbreviations	
LDAC	Liquid Desiccant Air Conditioning
TCOP	Thermal Coefficient of Performance
ECOP	Electrical Coefficient of Performance
LCCA	Life Cycle Cost Analysis
PID	Proportional Integral Derivative Controller
IEVC	Indirect Evaporative Cooler
VCC	Vapor Compression Cycle
PLR	Part load ratio

Introduction: