Renewable and Sustainable Energy Reviews 50 (2015) 277–303

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Progress and development in brick wall cooler storage system

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ARTICLE INFO

Article history:
Received 14 November 2014
Received in revised form
28 April 2015
Accepted 7 May 2015

Keywords:
Brick wall cooler storage system
Evaporating medium
Postharvest loss
Shelf-life
Solar adsorption
Fruit and vegetables

ABSTRACT

This paper carried out a review study into the brick wall cooler storage system (zero energy storage) in terms of its originality, current status, research and implementation achievement, benefit and possible barriers. The continuous progress in technology innovation, heat and mass exchanger of the brick wall cooler storage system now varied from sand–zeolite mixture, volcanic plate made wall, natural ventilation for releasing excess inside relative humidity, optimization of watering operation to save water and successful integration of the solar-driven adsorption cooling system with brick wall cooler storage system enhanced the cooling performance over those the decade ago by increasing the shelf-life of the stored fruit and vegetables. This review work indicated that the brick wall cooler storage system has potential to be an alternative to conventional electric powered expensive cooling storage for fruit and vegetables in the rural areas of the developing world. Future success on the dissemination of brick wall cooler storage system towards farmer's community may imply on more study on newer type of low cost heat exchanger material; further study on its economic, environment and social impacts; low cost postharvest treatment and packaging for brick wall cooler storage system; extensive farmers awareness and other dissemination measures; and public awareness and other dissemination measures.

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http://dx.doi.org/10.1016/j.rser.2015.05.019
1364-0321/

Nomenclature

q	weight of vapor transmitted through a unit area in unit time
P	vapor pressure, kPa
x	distance along the flow path, mm
W	total weight of vapor transmitted, g
A	area of cross-section of flow path, m^2
ΔP	partial pressure difference between ends flow path, kPa
L	thickness of the evaporative medium, m
M	permeance in g h^{-1} m^{-2} per vapor difference, kPa
M_a	mass of moist air, kg
V_a	velocity of air, m s^{-1}
W_o	humidity ratio of the air, kg of water kg of dry air^{-1}
P_A	effective evaporative medium surface area (m^2) expressed as $P_A = A_T \cdot P_E$
A_T	total evaporative medium surface area, m^2
P_E	evaporative medium efficiency (considered as the porosity of the material)
P_s	porosity of the evaporative medium, in decimal
h_a	enthalpy of moist air, kJ kg^{-1}
T_o	outside air temperature, °C
C_v	specific heat capacity of water vapor, kJ kg^{-1} °C
h_c	changes in enthalpy of the air with the respect to the change in evaporative medium thickness dP_T
$\frac{dT}{dP_T}$	change in the temperature of the air passing through the evaporative medium thickness dP_T
Q	rate of heat transfer from the air the evaporative medium, kJ s^{-1}
h^1	the convective heat transfer coefficient, kJ m^{-2} °C^{-1}
T_s	temperature of the air passing through the evaporative medium, °C
C_a	specific heat capacity of the air, kJ kg^{-1} °C^{-1}
M_T	mass of water evaporated by the air from the evaporated medium, kg s^{-1}
h_D	mass transfer coefficient, m s^{-1}
H_o	concentration of water vapor in the outside free stream, kg m^{-3}
H_p	concentration of water vapor in the boundary layer of the evaporative medium, kg m^{-3}
P_{vs}	saturation vapor pressure at the wet-bulb temperature, kg m^{-2}
P_{va}	partial vapor pressure of the water vapor in the unsaturated air stream, kg m^{-2}
M_w	molecular weight of water
R_o	universal gas constant, 8315 kJ kg^{-1} K^{-1} mol
T_{abs}	absolute temperature, calculated as the average temperature between the dry bulb and wet bulb, K
Q_w	heat required to evaporate the water from the evaporation medium, kJ
h_{fg}	heat of vaporization, kJ kg^{-1}
$T_{1(db)}$	dry-bulb of the ambient temperature, °C
$T_{2(db)}$	dry-bulb temperature of air inside the evaporative medium, °C
$T_{1(wb)}$	wet-bulb temperature of the ambient temperature, °C
Q_r	respiration heat load of the stored fruit and vegetables, W h^{-1}
M_p	mass of fruit and vegetables, kg
P_{re}	rate of respiration heat production, W kg^{-1} h^{-1}
Q_f	field heat picked up by fruit and vegetables, W
M_p	mass of fruit and vegetables, kg
C_p	specific heat capacity, kJ K^{-1} °C^{-1}
t_c	cooling time (s) for fruit, h
ΔT	change in temperature, °C
Q_L	heat transfer through cracks and opening of the storage cover, W
Q_{A-B}	heat supplied to heat activated carbon and methanol from point A to point B, °C
C_{ac} and C_r	heat capacities of activated carbon and methanol
M_{ac} and M_{rA}	masses of activated carbon and methanol adsorbed ($M_{rA} = x_A \cdot M_{ac}$), kg
T_{con} and T_{gen}	temperature of activated carbon and methanol-activated carbon temperature at points A and B, °C
Q_{B-C}	heat supplied to heat activated carbon and methanol, leading to desorption, °C
$\overline{M}_r$	average mass of methanol, which can be calculated approximately using $\overline{M}_r = (\overline{M}_{rB} + \overline{M}_{rC})/2$
T_{gen} and T_{max}	temperature of points B and C, °C
Δx	concentrated variation that is calculated by $\Delta x = x_B - x_C$
H_d	desorption heat constant for a given pair, kJ kg^{-1}
Q_{C-D}	heat removed from the activated carbon and methanol by an external cooling source, °C
T_{max} and T_{ads}	activated carbon temperature at points C and D, °C
Q_r	cooling output, kJ
L_o	latent vaporization of methanol (treated as a constant in ideal case analysis), kJ kg^{-1}
ΔM_r	mass of liquid methanol that equates to ($M_{rB} - M_{rC}$)
T_{con} and T_{ev}	condensing and evaporating temperature, °C
COP_s	solar coefficient of performance
I	total amount of heat input absorbed by the solar collector, MJ
M_{ice}	total amount of ice production, kg $cycle^{-1}$
C_{pw}	specific heat of water, kJ kg^{-1}
L_{fus}	latent heat of ice fusion, kJ kg^{-1}
C_{ice}	specific heat of ice respectively, kJ kg^{-1} K^{-1}

Greek symbols

μ	average permeability of material, g-mole m^{-2} h^{-1} kPa^{-1}
Θ	time of transmission, h
ρ_a	density of air, kg m^{-3}