



Progress and development in brick wall cooler storage system



Md. Parvez Islam*, Tetsuo Morimoto

Department of Biomechanical Systems, Ehime University, 3-5-7 Tarumi, Matsuyama 790-8566, Japan

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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* Corresponding author. Tel.: +81 89 946 9823; fax: +81 89 947 8748.

E-mail address: engr_parvezfpm@agr.ehime-u.ac.jp (Md.P. Islam).

Nomenclature

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

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