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Design and Development of a Cooler used for Air Cooling and Refrigeration

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***Abstract**: In this research paper we have discussed the utilization of a cooler for air cooling as well as refrigeration. The purpose of this paper is to design modification of the existing design of, in which a refrigeration box is made of mild steel is attached inside the cooler tank and this tank of cooler is insulated by rubber pad from outside to avoid any loss of heat. All the surfaces of the box are in contact with tank water except the front face which is door of a refrigeration box. The proposed model is experimentally validated by conducting a series of experiments in a controlled atmosphere inside a room in the climate of Raipur, Chhattisgarh, India. Box is loaded with fruits / vegetables and parallel to this, the same quantities of fruits / vegetables are kept outside in the room and daily weight loss is measured.*

Keywords:* Air cooler, *Evaporative cooling, Mathematical modeling and Refrigeration box.

I. INTRODUCTION

Evaporative air cooler generally referred as desert coolers. Nowadays it is very popular for space cooling providing a cheap alternative to standard air conditioning systems. It operates without the ozone harming hydro-chlorofluorocarbons (HCFCs) which is used by refrigeration based systems as compare to air conditioning (AC) units. Northern regions of India are the very good locations for execution of this device when sufficient amount of water is available, low installation and operating cost in this region than the AC units. Although the utilization of desert coolers for space air conditioning is an effective alternate to compressors-based air conditioning systems but still the poor effectiveness of the evaporative cooling-based desert cooler in humid climatic conditions is one of the reasons for the decline in popularity of evaporative cooling-based device. Still it is suitable in many parts of the country due to favorable climatic conditions; it may be categorized as direct evaporative cooling system and indirect evaporative cooling system. Direct evaporative cooling introduces water directly into the supply airstream. Water absorbs heat from supply air; it evaporates and cools the air. Indirect evaporative cooling lowers the temperature of air by the arrangement of some type of heat exchangers; secondary sir is cooled by water and then successively cools the primary air.

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II. LITERATURE REVIEW

Classic book by Watt [1] is an excellent qualitative review of the various concepts, devices and systems, which had been in vogue by that time, though the corresponding quantitative analysis was missing. The two papers by Mathur and Jain [2, 3] presented mathematical model showing the performance of the air cooler fitted in a room, are typical publications in this area in 70s and early 80s. Singh et al [4] investigated the dependence of tropical summer index (TSI) in a room cooled by air washer type air cooler. Optimum values of the operating parameters viz packing factor, pad area, and the airflow rate for which the mean daily TSI is minimum has been determined for a typical set of a cooler, room and meteorological conditions. Singh et al [5], developed a mathematical model characterizing optimization of the cooling performance of air cooler, and defined two new conditions which determine the cooling capacity of this cooler. Dowdy et al [6] evaluated heat and mass transfer coefficient by conducting experiments with the help of various types of cellulose pads thickness. Sodha et al [7] analyzed the cooling tower's thermal performance which is fitted in the building in terms of discomfort index for dry and warm climates. Singh, Tulsidasni, Swhney and Sodha [8-13] in series of 6 papers reported their work on optimization of coefficient of performance (COP), cooling potential, thermal performance in building, recirculation effect on cooled room and design evolution has been investigated in IEC (Indirect Evaporative Cooling) system. Plasencia et al [14] developed a new model which is based on transfer of heat and mass for IEC; few simplifications were incorporated to make this model as user friendly used for analysis of energy as well as adaption of system. Camargo et al [15] presented an operational concept for both type of cooling systems and generated equations for mass and heat transfer between warm air and wetted media. Above researches and mathematical models has been limited up to the conditioning of air coming out of the coolers, and to increase the saturation efficiency or effectiveness of cooler; however the use of cooled water stored in tank was not at all explored. This gap of not using the coolness of cooler water has been identified as a research gap and thus becomes the main objective of the present work.

The coolness stored in tank water can be utilized for mild refrigeration or to cool. As in present work it is suggested that the cooler water can be utilized to cool the objects stored in the cooler tank.

III. MATHEMATICAL MODELING

A. Determination of exit air temperature of cooler and exit water temperature on pad

Following earlier mathematical model proposed by Sodha and Somwanshi (2012), considering an evaporative pad (Fig. 1), having water flow from up to down tray in z direction, flow of water is normal to the pad in x direction. Dependence of water temperature on z direction is taken into consideration.

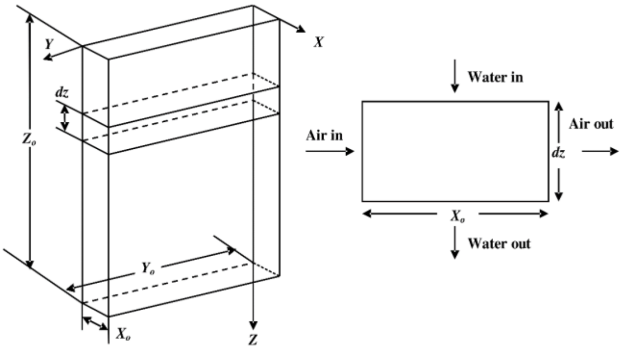


Fig.1 Pad profile and elemental volume

The temperature of inside air to the pad is given by Wu et al. (2009)

$$\frac{T_a - T_w}{T_{ai} - T_w} = \exp(-\alpha x), \quad (1)$$

where $\alpha = h_c F_p / \rho_a v_a$ .The term T_{ai} is just the inlet atmospheric air temperature,

From Eq. (1) mean and exit air temperature is given

$$T_{ae} = T_w \{1 - \exp(-\alpha x_o)\} + T_{ai} \exp(-\alpha x_o) \quad (2)$$

$$\bar{T}_a = T_w + \{T_{ai} - T_w\}\{1 - \exp(-\alpha x_o)\} / \alpha x_o, \quad (3)$$

Average of x is indicated by the bar.

thickness of pad dz (fig. 1) is considered, and for water engery balance equation is expressed as,

$$\dot{m}_w c_w \frac{dT_w}{dz} dz + \dot{Q}_L dz + \dot{Q}_S dz = 0; \quad (4)$$

Tiwari gives an equation for mass transfer which is associated by heat transfer per unit area, (2002)

$$\dot{q}_L = C_n h_c (P_w - \gamma P_a). \quad (5)$$

C_n is a constant and it is given by,

$$C_n = \frac{M_w L}{RT \rho_a c_{pa} Le^{2/3}}$$

$$\rho_a = \frac{P_a M_a}{RT}$$

$$C_n = \frac{L}{c_{pa}} \frac{M_w}{M_a} \frac{1}{P_T Le^{2/3}} \text{ here } P_a = P_T$$

$$Le = \frac{\alpha'}{D_{ab}}$$

Remembering that the evaporating surface in the element $x_o y_o dz$ is $F_p x_o y_o dz$.

$$\dot{Q}_L = \dot{q}_L F_p x_o y_o$$

$$= C_n h_c (P_w - \gamma P_a) F_p x_o y_o; \quad (6)$$

further,

$$\dot{Q}_S = h_c (T_w - T_a) F_p x_o y_o. \quad (7)$$

The saturation vapor pressure of water can be represented by good approximation

$$P = R_1 T^2 + R_2 T + R_3, \quad (8)$$

where $R_1 = 6.36 Nm^{2o} C^{-2}$, $R_2 = -112.8 Nm^{2o} C^{-1}$ and $R_3 = 1890 Nm^{-2}$.

From Eqs.(3),(4),(5),(6),(7) and (8) one obtains,

$$\frac{dT_w}{dz} = -AT_w^2 + BT_w + C, \quad (9)$$

where,

$$N_1 = \frac{\dot{m}_w c_w}{h_c F_p x_o y_o},$$

$$K_1 = \{1 - \exp(-\alpha x_o)\} / \alpha x_o,$$

$$A = R_1 C_n / N_1,$$

$$B = (R_2 C_n - K_1) / N_1 \text{ and}$$

$$C = [C_n R_1 \gamma T_{ai}^2 + T_{ai}(K_1 - \gamma C_n R_2) + C_n R_3 (\gamma - 1)] / N_1$$

Integrating Eq.(9) one obtains,

$$\frac{T_w - (B/2A) - C_1}{T_w - (B/2A) + C_1} = \beta \exp(-2AC_1 z),$$

where,

$$\beta = \frac{\left[T_{wi} - (B/2A) - C_1\right]}{\left[T_{wi} - (B/2A) + C_1\right]},$$

and

$$C_1 = \sqrt{(B/2A)^2 + C/A},$$

where T_{wi} represents as temperature at the upper side of cooling pads ($z = o$)

From Eq. (9) the exit and mean water temperature flowing in the cooling pad and mean exit air temperature is given by,

$$T_{we} = (B/2A) + C_1 \left\{ \frac{(1 + \beta \exp(-2AC_1 z_o))}{(1 - \beta \exp(-2AC_1 z_o))} \right\} \quad (10)$$

$$\langle T_w \rangle = \frac{B}{2A} + \frac{1}{Az_o} \ln \left\{ \frac{\exp(2AC_1 z_o) - \beta}{1 - \beta} \right\} - C_1, \quad (11)$$

$$\langle T_a \rangle = \exp(-\alpha x_o)\{T_{ao} - \langle T_w \rangle\} + \langle T_w \rangle. \quad (12)$$

C_n is a constant and it is given by,

$$C_n = \frac{M_w L}{RT \rho_a c_{pa} Le^{2/3}}$$

c_{pa} is represents as specific heat of moist air given by Gvozdenac [9],

$$c_{pa} = [(1.0029 + 5.4x10^{-5} T) + \xi(1.856 + 2.0x10^{-4} T)] kJ / kgK$$

$$\rho_a = \frac{P_a M_a}{RT}$$

$$C_n = \frac{L}{c_{pa}} \frac{M_w}{M_a} \frac{1}{P_T Le^{2/3}} \text{ here } P_a = P_T$$

$$Le = \frac{\alpha'}{D_{ab}}$$

α' represents as thermal diffusivity and D_{ab} is diffusion coefficient of water vapor in air and it is given by Boltz and Tuwe [10],

$$D_{ab} = -2.775x10^{-6} + 4.479x10^{-8}T + 1.656x10^{-10}T^2$$

here T is the temperature in Kelvin.

B. Determination of box temperature and tank water temperature

Rate of heat given by refrigeration box (Load) will be,

$$\dot{Q}_h = U_x[T_h(t) - T_t(t)] \tag{13}$$

$\dot{Q}_h$ is heat transfer rate from refrigeration box to surroundings, T_h and T_t are the temperature inside box and surrounding tank water temperature, U_x is given by,

$U_x = U(2A_h + 4A_s)$, when rectangular box is completely surrounded by tank water (Experiment)

$U_x = U(2A_h + 3A_s)$, one of the vertical face is insulated and exposed to atmosphere, door of refrigerator box. (Fig.3)

Here, A_h and A_s are area of horizontal and vertical faces of box. U is represents as heat transfer coefficients between water and refrigeration box. The energy balance equation for cooler tank is,

$$M_t c_w \frac{dT_t}{dt} = Q_h + Q_m - Q_e \tag{14}$$

Q_m is the rate of heat added by make-up water,

$$Q_m = m_m c_w (T_a - T_t) \tag{15}$$

m_m is the mass of make-up water added per sec. T_a is the initial make-up water temperature assumed equal to ambient $T_a = T_{ai}$

Q_e is the rate of evaporative heat transfer from tank water through cooler pads

$$Q_e = m_c c_w (T_{pi} - T_{we}) \tag{16}$$

m_c is rate of mass flow of tank water flowing into cooler pads, T_{pi} is tank water temperature into cooler pad and T_{we} is exit water temperature of cooler pad.

Neglecting pumping and pipe loses inlet water temperature in pad will be equal to temperature of tank water $T_t = T_{pi}$.

From Eqs. 2, 3 4 and 5,

$$M_t c_w \frac{dT_t}{dt} = \dot{Q}_h + m_m c_w (T_a - T_t) - m_c c_w (T_{pi} - T_{we}) \tag{17}$$

$$\frac{dT_t}{dt} + K_1 T_t = K_2$$

$$K_1 = \frac{m_m c_w}{M_t c_w}$$

$$K_2 = \frac{\dot{Q}_h + m_m c_w T_a + m_c c_w T_{we} - m_c c_w T_{pi}}{M_t c_w}$$

$$T_t = \frac{K_2}{K_1}\{1 - \exp(-K_1 t)\} + T_{t0}\exp(-K_1 t) \tag{18}$$

By putting the value of T_t, Eqn. 1, the temperature inside the refrigeration box is given by,

$$T_h(t) = \frac{Q_h}{U_x} + T_t(t) \tag{19}$$

C. Determination of root mean square of percentage deviation (e) and correlation coefficient (r)

Closeness of theoretical and experimental values can be presented in terms of root mean square of percentage deviation (e) it's given by Tiwari [9],

$$e = \sqrt{\frac{\sum (e_i)^2}{n}}$$

$$e_i = [\frac{X_{pre(i)} - X_{\exp t(i)}}{X_{pre(i)}}] \times 100$$

Relationship between theoretical and experimental values is presented by a coefficient called as correlation coefficient (r). If the value of r is close to 1, then the theoretical and experimental values are in strong correlation. Correlation coefficient may be determined with the help of below expression as given by Tiwari [12],

$$r = \frac{N\sum X_{pre}X_{\exp} - (\sum X_{pre})(\sum X_{\exp})}{\sqrt{N\sum X_{\exp}{}^2 - (\sum X_{\exp})^2}\sqrt{N\sum X_{pre}{}^2 - (\sum X_{pre})^2}}$$

Here N is number of observations.

D. Proposed design of cooler

Cubical air cooler which is the most commonly used cooler can be modified to a cooler which serves dual purpose of cooling air as well can be utilized as mild refrigeration. In desert cooler air is coming out by the fan, this air continuously cooled due to evaporation of water droplets trickling down the evaporative pads. Heat and mass transfer principle gives the result to cool the water & air. Cooled tank water is stored in the tank of cooler and not generally utilized. The new proposed design of cooler can be utilized as air-cooler as well as refrigerator. It is shown in figure (2).

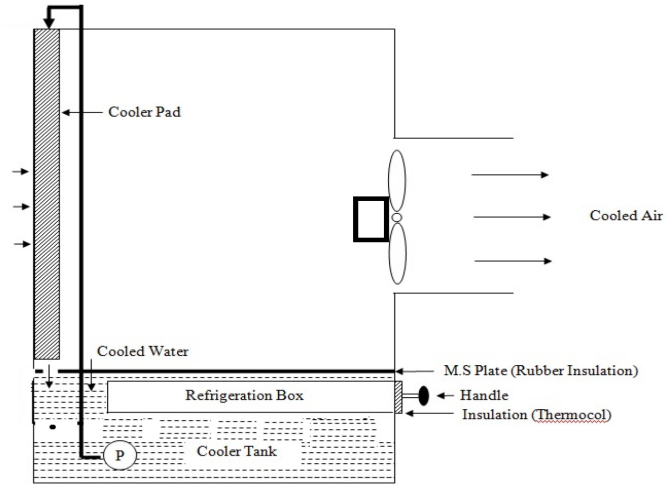


Fig. 2 Proposed design of cooler

IV. FABRICATION AND EXPERIMENTAL SETUP

A. Fabrication of Experimental cooler

Experimental cooler is fabricated to conduct the experiments in stable conditions. To fabricate the air cooler as proposed the following cooler parts has been selected a detailed criterion of selection is discussed below

1) Cooling Pad

Cooling pads are the material which is used in the cooler in which water is flowing by any medium and then pads gets wetted, this wetted pads coming in contact with air stream then air gets cooled, it may decrease the temperature about 10 to 20^{0}C. There are mainly two types of cooling pads are used in cooler.

i. Aspen cooling pad
ii. Cellulose pad (Honeycomsb pad)

i. Aspen cooling pads

Aspen cooling pads are made up of synthetic fiber and wood, and looks like a grass. Aspen cooling pads are cheap and economical, this is the reason Aspen cooling pads coolers are cheap but it require high maintenance and it is less durable material. Aspen pads are less effective than the cellulose pads.

Fig. 3 Aspen pad

ii. Cellulose pads

It is made up of cellulose material and also called honeycomb pads, it is very effective in cooling and require high maintenance or cleaning. This is high durable material and more effective than the aspen cooling pads. In desert air coolers cellulose pads are used because of their cooling potency of air in large scale.

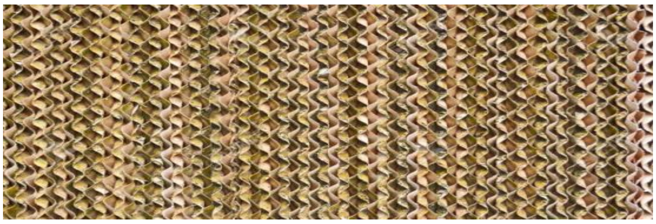


Fig. 4 Honeycomb pad

B. Motor, Pump, Fan

Other parts include the selection of motor driven exhaust fan to drive the flow of air into the room to be cooled. A pump is used for water carrying from tank of cooler to top distribution systems, where it is distributed to the three different pads.

Fig. 5 Fan, Motor, Pump

C. Refrigeration box

The box we used in this project is made up of G.I. Sheet which is in rectangle shape, which is to be kept inside the cooler tank for that purpose it has been fully insulated, so that we kept it inside the water. Inside the box we have fitted two bulbs are fitted of 5W & 10W and also a sensor is fitted for taking the reading of temperature inside the box. The box is having the sizes (Length=30cm, Breadth=35cm, Height=10cm).

Fig. 6 Refrigeration box

D. Experimental Setup

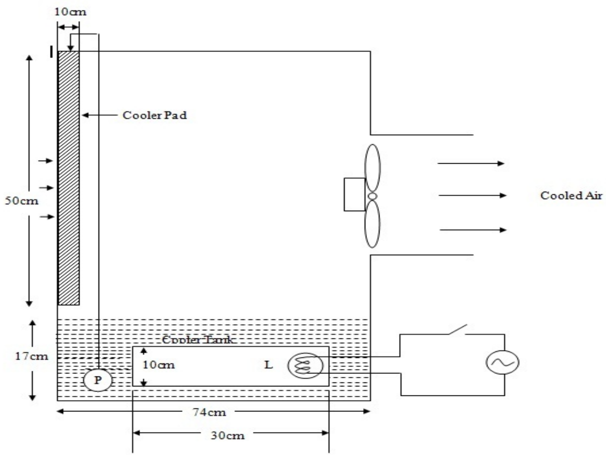


Fig. 7 Experimental cooler with loaded refrigeration box

The rectangular refrigeration box is attached as shown. Capacity of the refrigeration box will depend on the size of the cooler tank however, in the present work for further computations a mid-size cooler is considered and the capacity of refrigerator box is taken as 30L. All surfaces of the box are in contact with tank water except the front face which is door of a refrigerator box.

Tank of cooler is insulated by rubber pad from outside to avoid any loss of heat. To analyze the performance of refrigerator, hot water with initial temperature as ambient is considered inside the refrigeration box.

V. EXPERIMENTAL VALIDATION AND NUMERICAL COMPUTATION

To validate the mathematical model proposed in series of experiments were performed in controlled atmosphere inside a room in the climate of Raipur (Chhattisgarh), India. The experiment cooler has tank capacity of 90L is cubical shaped with the cellulose paper pad as evaporative media. An exhaust fan (100W) has been fixed in the front face to induce the hot air coming into the cooler pad.

A pump (40W) is placed into the tank of the cooler to allowing the flow of water from upside to downside into cooler pad. This cooler pad comes in contact of air there will be transfer of heat and mass between air and water as result of this both air and water gets cooled. In cooler's tank this cooled water is stored. The proposed method is to use stored cool tank water. A refrigeration box made of mild steel plate is clamped inside the tank of the desert cooler as shown in figure (6). To simulate the refrigeration load electric bulbs (5W and 10W) is placed inside the refrigeration box. Temperature sensors are fixed inside the box to measure the transient temperatures of enclosure in the box. To measure the temperature of tank water temperature sensor is placed inside the tank of the cooler. Cooler was kept in a small room, having exit air duct. This duct is going out of the room to provide stable conditions inside room. Air is coming into the cooler from an open window opposite to the cooler. To determine the humidity and temperature of inlet air RTD sensors which have 0.2% to 1% accuracy and digital hygrometer with 5% accuracy are fixed at three different points inside room. The temperature of exit air was measured by two temperature sensors kept in exit air duct. Velocity of inlet air was measured by electronic type digital anemometer with 5% accuracy. The incident air velocity on pad is used for computing convective heat transfer coefficient h_c between pad material and air. Two RTD temperature sensors are kept inside refrigeration box to measure the temperature of enclosure. Cooler is enclosed by evaporating pad of dimensions $(0.50\times0.45\times0.10)m^3$. Front side is provided with an exit air duct with a fan (Crompton, 1400 RPM), connected to draw in outside air (warm air) into the cooler pad. A pump (Bajaj, 40W) is placed inside the cooler tank (0.74mx0.74mx0.17m) to feed water from tank into the cooler pads. The pad is made of honeycomb cellulose paper with an evaporating surface of 370 $m^2 m^{-3}$ (curtsey manufacturer) and convective heat transfer coefficient h_c given by [10],

$$Nu = 0.10\left(\frac{l_e}{l}\right)^{0.12} \mathrm{Re}^{0.8}\, \mathrm{Pr}^{1/3}$$

$$l_e(Charterstic length) = \frac{V_o}{A_p}$$

Here, le is characteristic length, l is thickness of pad which is equal to x_0, ratio $\frac{V_o}{A_p}$ is the ratio between volume occupied by pad material and total wetted surface area (m^3/m^2)

Rate of mass flow of flowing water in pads is computed by measuring time taken. Tank water temperature, exit air temperature and preservation temperature (inside box) with load is recorded at the time interval of 5mins. Cooler is allowed to run for 5mins only through pump to keep pads uniformly wet before starting the experiment. Computed and recorded preservation temperature, tank water temperature and exit air temperature at two different loads 5W and 10W are shown in tables 1-2 and relationship between theoretical and experimental temperature inside box w.r.t. time are shown in graph 1-2.

Table-1 Theoretical and experimental temperature inside box, tank water and exit air with 5W Load

$(T_a = 30.6^oC, \gamma = 38\%,\ v_a = 1.5m/s)$

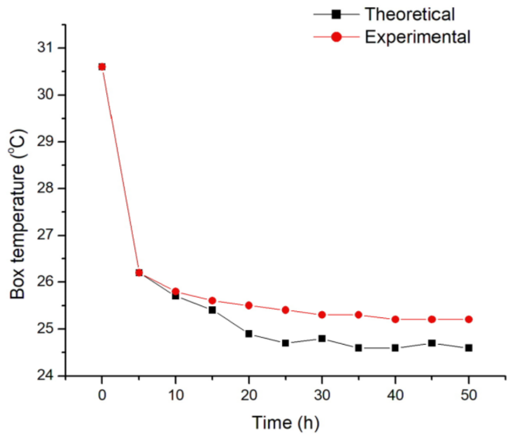
Time (m)	Box temperature (°C)		Tank water temperature (°C)		Exit air temperature (°C)	
	Ex.	Th.	Ex.	Th.	Ex.	Th.
0	29.8	29.8	30.5	30.5	30.6	30.6
5	28.4	27.6	27.5	26.3	26.2	26.2
10	26.5	25.2	24.4	23.9	25.7	25.8
15	24.3	23.8	22.4	22.5	25.4	25.6
20	23.2	23.0	21.6	21.7	24.9	25.5
25	22.8	22.5	21.5	21.2	24.7	25.4
30	22.6	22.2	20.6	20.9	24.8	25.3
35	21.8	22.0	20.5	20.8	24.6	25.3
40	21.6	22.0	20.5	20.7	24.6	25.2
45	21.5	21.9	20.4	20.6	24.7	25.2
50	21.4	21.8	20.5	20.5	24.6	25.2
e	2.44		3.17		1.90	
r	0.98		0.97		0.96	

Table-2 Theoretical and experimental temperature inside box, tank water and exit air with 10W Load

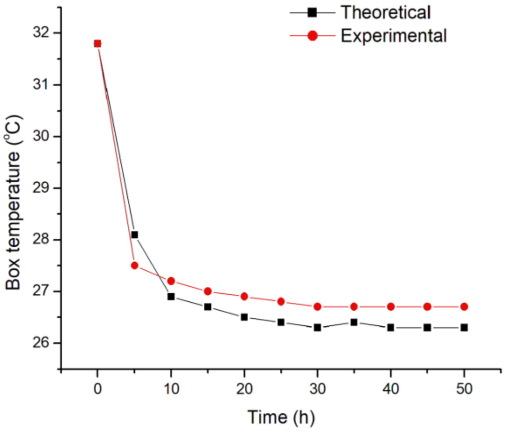
$(T_a = 31.7^oC, \gamma = 42\%,\ v_a = 1.5m/s)$

Time (m)	Box temperature (°C)		Tank water temperature (°C)		Exit air temperature (°C)	
	Ex.	Th.	Ex.	Th.	Ex.	Th.
0	31.4	31.4	32.6	32.6	31.8	31.8
5	30.5	30.9	27.9	28.3	28.1	27.5
10	29.3	28.3	25.5	25.7	26.9	27.2
15	27.2	26.9	24.0	24.3	26.7	27.0
20	25.8	26.0	23.8	23.4	26.5	26.9
25	25.5	25.5	23.4	22.9	26.4	26.8
30	25.3	25.2	23.0	22.6	26.3	26.7
35	25.0	25.0	22.9	22.5	26.4	26.7
40	24.8	25.1	22.7	22.4	26.3	26.7
45	24.5	24.9	22.6	22.3	26.3	26.7
50	24.5	24.8	22.7	22.3	26.3	26.7
e	2.10		2.06		1.72	
r	0.98		0.99		0.98	

Graphical representation of theoritical and experimental box temperature



Graph 1. Relationship between theoretical and experimental temperature inside box w.r.t. time for 5W Load



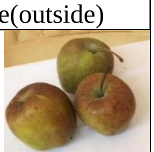
Graph 2. Relationship between theoretical and experimental temperature inside box w.r.t. time for 10W Load

VI. PERFORMANCE OF LOADED BOX

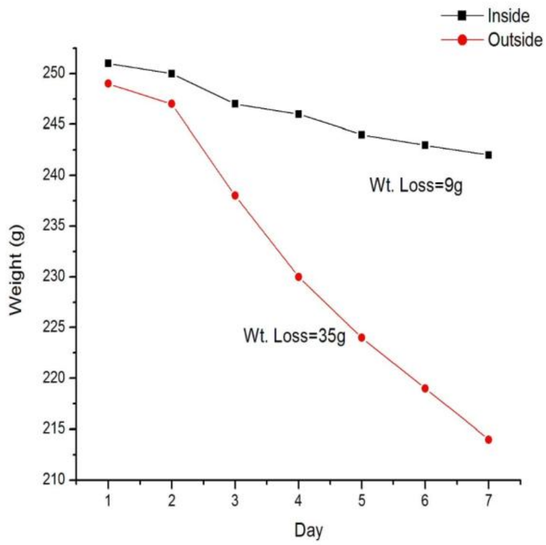
Refrigeration box is loaded with apples and the freshness of the stuff stored is observed daily. To save the electric power the fan of the cooler is kept off during night time and the pump of the cooler is kept on the water stored in the tank water is pumped in to the top and circulated through cooler pad. The water and air get cooled naturally by coming in contact with surrounding air. The fan of cooler is kept on for all the day during night it is kept off. The weight of the fruits stored is measured daily and the loss in weight is determined. The photographs of the stored items are shown in the Table 3 and the graph showing the weight loss in Graph 3

To determine the actual performance of the refrigeration box placed in the cooler tank experiments were performed with loaded refrigeration box. In the experiment box is loaded with apples (fruits) and parallel to this, same quantity of apples is kept outside in the room. The daily weight loss by the fruits is measured and the photographs of the fruits stored are taken. The experiment was performed continuously for a week.

Table-3 Determination of daily weight loss by apple

Dates	Weight of Apple (inside box)	Weight of Apple(outside)
24-04-2019	251g 	249g 
25-04-2019	250g 	247g 
26-04-2019	247g 	238g 
27-04-2019	246g 	230g 
28-04-2019	244g 	224g 
29-04-2019	243g 	219g 
30-04-2019	242g 	214g 

Graphical representation of weight loss between inside and outside apples



Graph 3. Weight loss by apple w.r.t. days

Set of experiments were perform to determine the freshness of stored products upside clay pot as proposed by author. Experiment was performed by loading pot with apples. In orders the product stored to assistant the quality of the product preserved in the pot .The present used products is compared with those kept outside in the same environment.

Freshness of apples is shown in table 3 and daily weight loss is shown in graph 3.

VII. RESULTS AND DISCUSSION

It is seen from Table 1-2 and Graph 1-2, that as a result of evaporation of water in pads, both temperature of tank water and exit air decreases and consequently the space inside box is also cooled this gives result of transfer of heat from box to tank water. Rate of cooling is more in the beginning and temperature inside the box becomes almost constant within 30 to 35mins. Degree of cooling depends on the rate of cooling of tank water due to evaporation in cooling pads. It is influenced by the climatic parameters (outside temperature, relative humidity) as well as heat transfer coefficient between pad material and air. Experimental and theoretical values are nearly close to 1.

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From Table 3 it is seen that the weight loss from apples kept outside is more in comparison to the apples stored in the refrigeration box. The weight loss in seven days is about 35g when kept outside where as weight loss is only 9g when stored inside box. Graph 3 shows temperature of inside apples is decreasing and the outside apples temperature increasing continuously. Apples of inside the refrigeration box are in good condition in compare of outside apples.

VIII. CONCLUSION

In present work a model of a dual purpose cooler utilized for air conditioning as well as refrigeration has been prepared. This air cooler can be used to store fruit / vegetables etc. In present work thermal performance of the cooler has been determined and following conclusions have been drawn:

1) Mathematically of the proposed cooler utilized for air cooling and refrigeration has been developed by writing equations of energy balance for the various parts.
2) The mathematical model has been validated by conducting a series of experiments under a small room in an experimental test rig, to simulate the refrigeration load electric bulbs (5W and 10W) has fixed inside the refrigeration box. It is seen that the experimental value are reasonably close to theoretical value, the value of "e" comes in between 1.72 to 2.68 and coefficient of correlation (r) value is in between 0.91 to 0.99 and it's close to 1.
3) In this experiment it is seen that the weight loss from apples kept outside is more in comparison to the apple stored in the inside of refrigeration box, the temperature of apples is decreasing when it kept inside the box and the temperature of apples in increasing when it kept outside. Apple are in good condition in compare of outside apples, the weight of inside are decreasing less than in compare of outside.

IX. FUTURE SCOPE

In this project, perception of room cooling and refrigeration box was made for storage of biodegradable items especially foodstuffs. Optimization of operating parameters may be used to build a useful and cost effective system.

REFERENCES

1. Watt JR, "Evaporative Air Conditioning", The Industrial Press, New York, 1986.
2. Mathur ML and Jain BP, "Performance of a portable cooler: desert cooler", Journal of Institute of Engineers (India), 241-245 (1979).
3. Mathur ML and Jain BP, "Experimental study of performance of portable air washer type air cooler", Journal of Institute of Engineers (India), 38-40 (1982).
4. Singh SP, Sawhney RL, Bansal NK, Sodha MS, "Sizing of an evaporative cooler for thermal comfort inside a room", Housiong Science, 141-148 (1987).
5. Singh SP, Sawhney RL, Bansal NK, Sodha MS, "Optimization of an evaporative cooler for space cooling", Housing Science, 225-231 (1987)'
6. Dowdy JR and Karabash NS, "Experimental determination of heat and mass transfer coefficients in rigid impregnated cellulose evaporative media", ASHRAE Transactions, 382-395 (1987).
7. Sodha MS, Singh SP, Sawhney RL, "Evaluation of design patterns for direct evaporative coolers", Building and Environment,278-291 (1995).
8. Singh SP, Tulsidasani TR, Swahney RL, Sodha MS, "Recent research on IEC Part-I: Optimization of the COP" (1997).
9. Singh SP, Tulsidasani TR, Swahney RL, Sodha MS, "Recent research on IEC Part-II: Thermal performance of a non-conditioned building coupled with an IEC" (1997).
10. Singh SP, Tulsidasani TR, Swahney RL, Sodha MS, "Recent research on IEC Part-III: Optimization of the cooling potential of a room-coupled IEC" (1998).
11. Singh SP, Tulsidasani TR, Swahney RL, Sodha MS, "Recent research on IEC Part-IV: Effect of recirculation on cooling of a room coupled to an IEC" (1997).
12. Singh SP, Tulsidasani TR, Swahney RL, Sodha MS, "Recent research on IEC Part-V: Relative thermal performance of buildings coupled to direct and indirect evaporative cooler" (1997).
13. Singh SP, Tulsidasani TR, Swahney RL, Sodha MS, "Recent research on IEC Part-VI: Evolution of design pattern for IEC" (1999).
14. Alonso JS, Martinez FR, Gomez EV, Plasencia MA, "Simulation model of an IEC", Energy and Buildings, (1998).
15. Camargo JR and Ebinuma CD, "A mathematical model for direct and indirect evaporative cooling AC systems", Thermal Engineering and Sciences, Caxambu, Brazil, (2002).
16. Riangvilaikul B and Kumar S, "An experimental study of a novel dew point evaporative cooling system", Energy Build, 637-644 (2010).

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