न हि ज्ञानेन सदृशं पवित्रमिह विद्यते।

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DEVELOPMENT OF OSCILLATING BED SOLAR DRYER

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FLOW OF PRESENTATION

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ABSTRACT

We manufacture optimum quality solar dryers which are the best ways to dry the fruits, spices etc easily and without any power consumption. A transparent Film which is used to cover the Solar Drying sheds. It is more transparent thereby the heat or sunlight easily gets into the chamber which is retained inside. There is no air pollution when you dry your products under this solar drying shed, which is very cheap and efficacious. Our solar dryers are ideal for all Agriculture products.

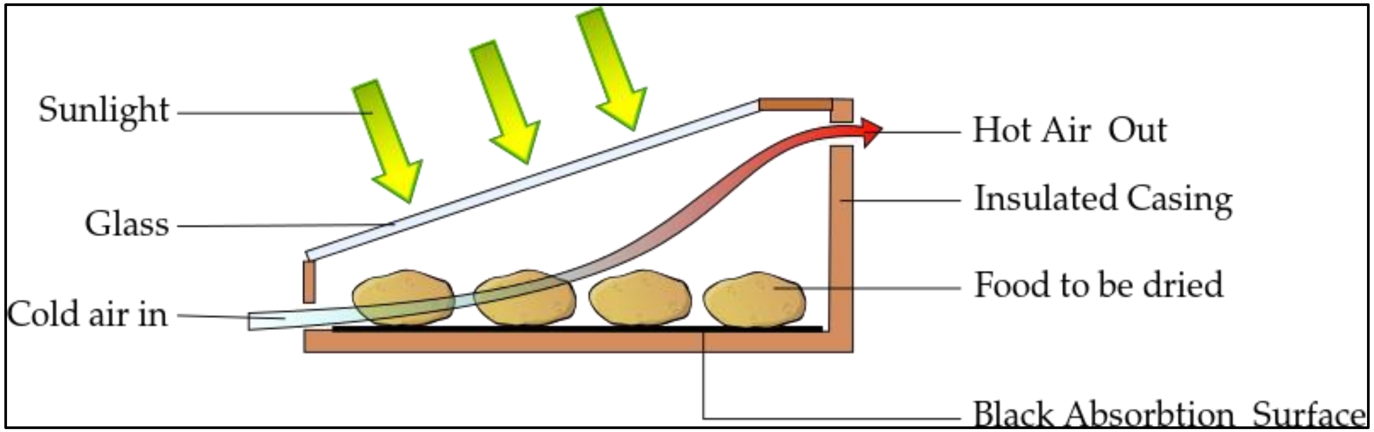
By use of $1m^2 x 1m^2$ solar collector with oscillating plate, efficiency is increase and reduce the time period of drying process.

OBJECTIVE

- Improve the quality of product.
- Increase the speed of drying of product.
- Increase the efficiency of solar dryer by use of oscillating bed.
- Moisture content can be controlled easily.
- Achieve the uniform drying and reduce the over drying of food products.

INTRODUCTION

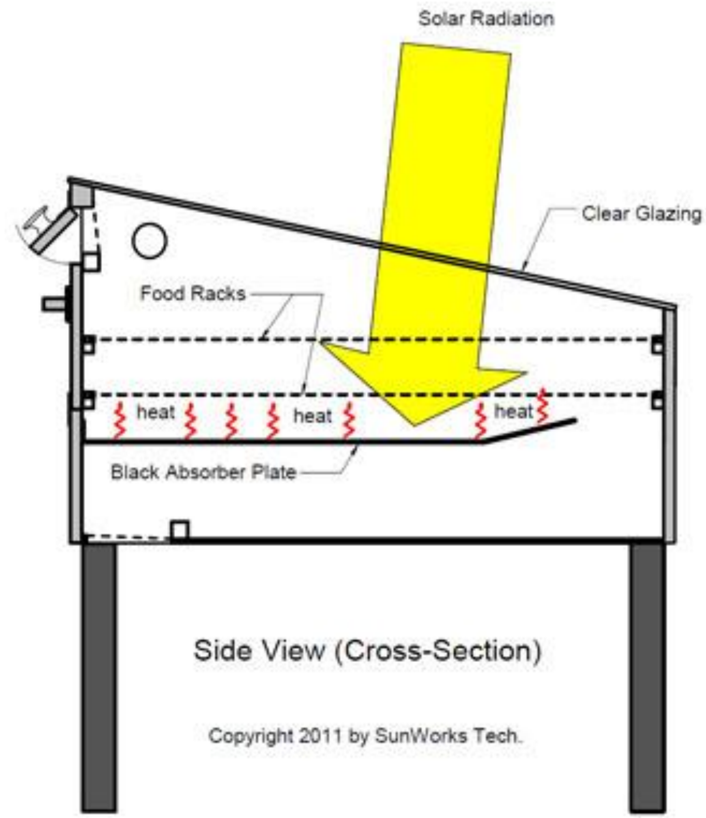
- Solar dryer is device that can used to convert solar energy into heat energy for drying agriculture products like foods, vegetables etc.



- Types of solar dryer
  - Direct solar dryer
  - Indirect solar dryer

Introduction cont…

- Direct solar dryer:-



[Fig. Direct solar dryer]

"These types of solar dryer does not use any external power for running any electrical device."

These are suitable for drying the food products on small scale e.g. conversion of

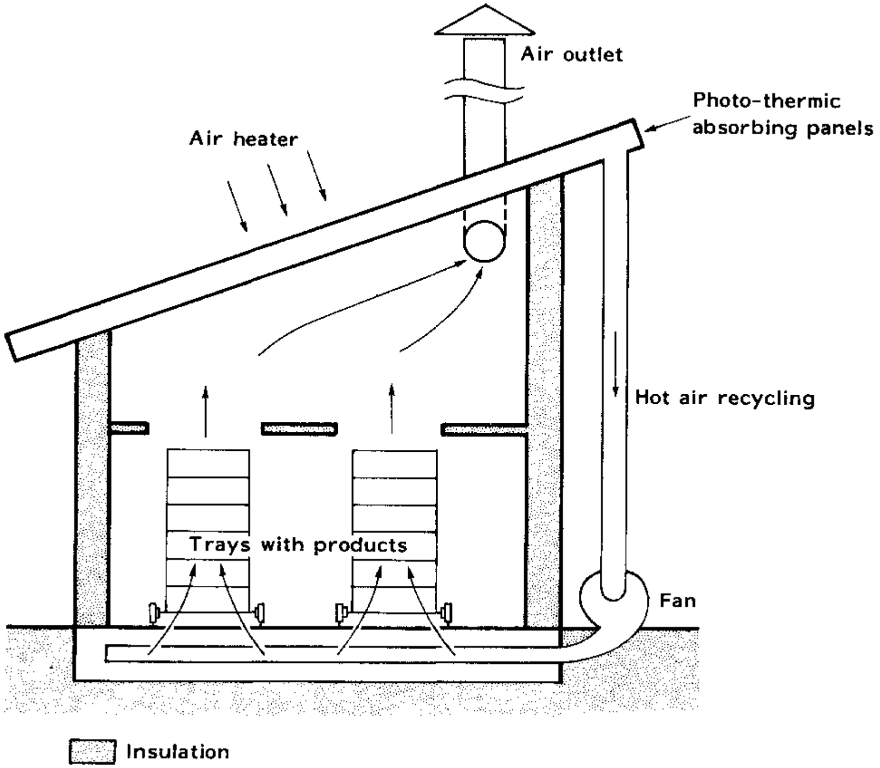
grapes into resins, drying of chilies.

- Indirect solar dryer:-

"Solar dryer are used for large scale drying of food products since the convection types Solar dryer are not found to be suitable"

-Rate of drying and efficiency is high compare to direct solar dryer.

- This types of dryers are used for drying the timber, bamboo, grains etc.



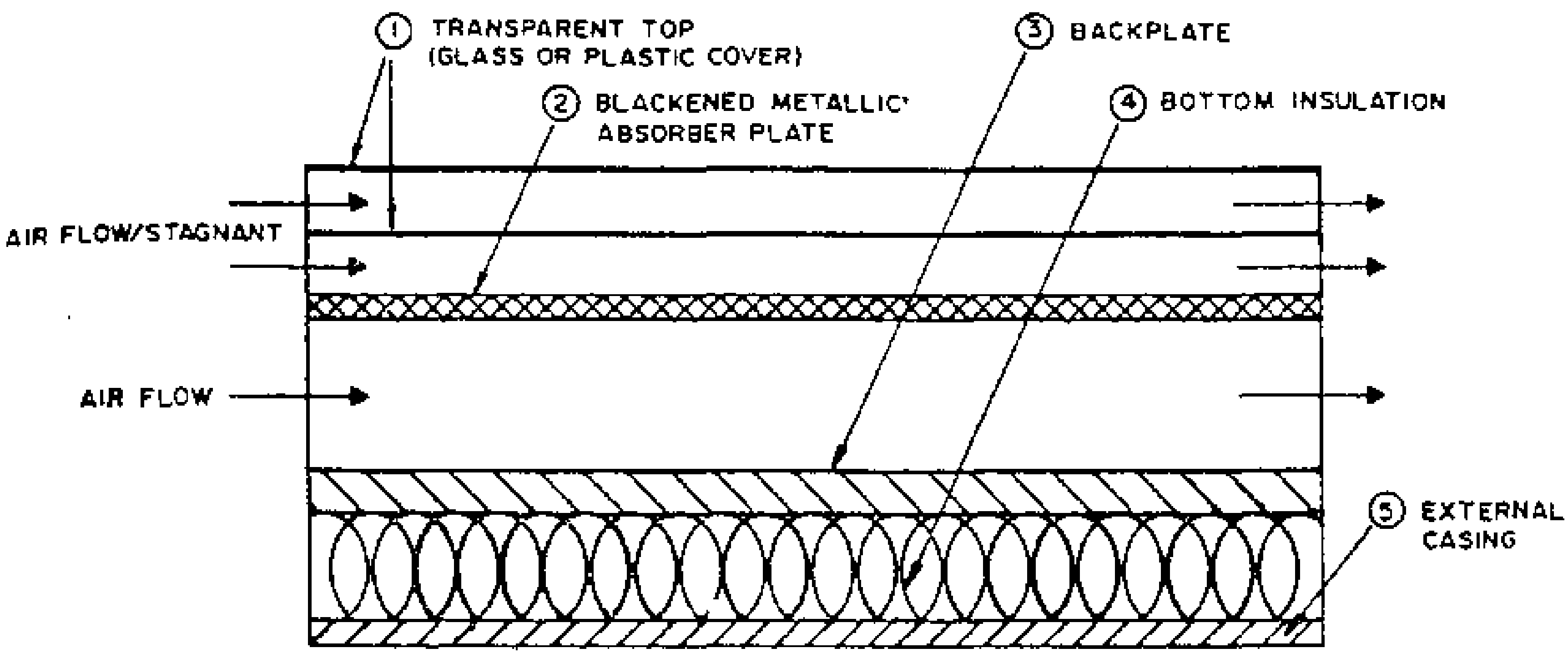
[Fig. indirect solar dryer]

BACKGROUND

- It is estimate because 20% of the food product is wasted during the post harvest period.
- Agricultural product and food loose their spillage, contamination, attack by birds and insects.
- In previous food preservation, traditional method is used for drying of food product in sun.
- Causes over drying of food, it causes discolorations, nutritional changes, lose of germination etc.

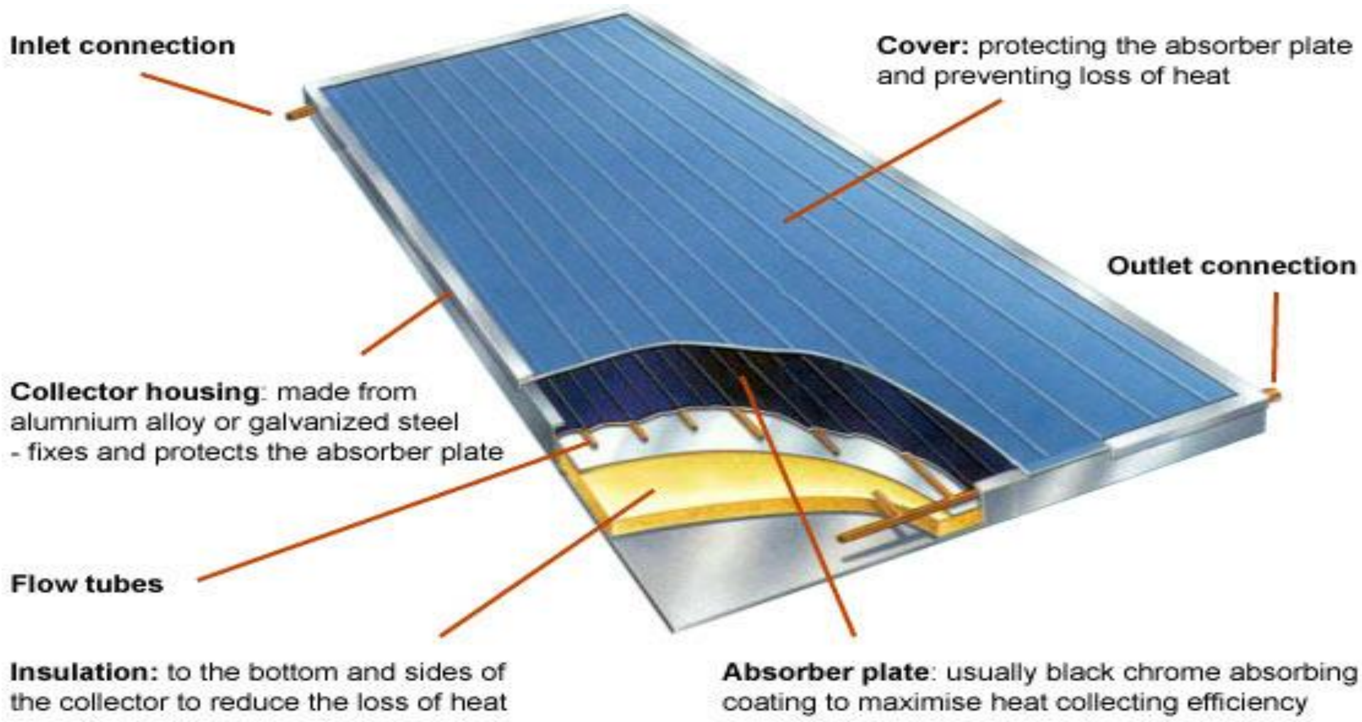
SOLAR AIR HEATERS:

Solar air heater is a device to produce hot air for any industrial or farmer level drying applications by using freely available SUN, without using any conventional fuels like electricity, diesel, LPG, firewood, coal, etc., But It could be coupled with an existing conventional drying systems like Tray driers, Tunnel Driers, Conveyor Drier, FBD drier and bin drier operated by conventional fuels to save fuel consumption.



[Fig. Solar Air heater]

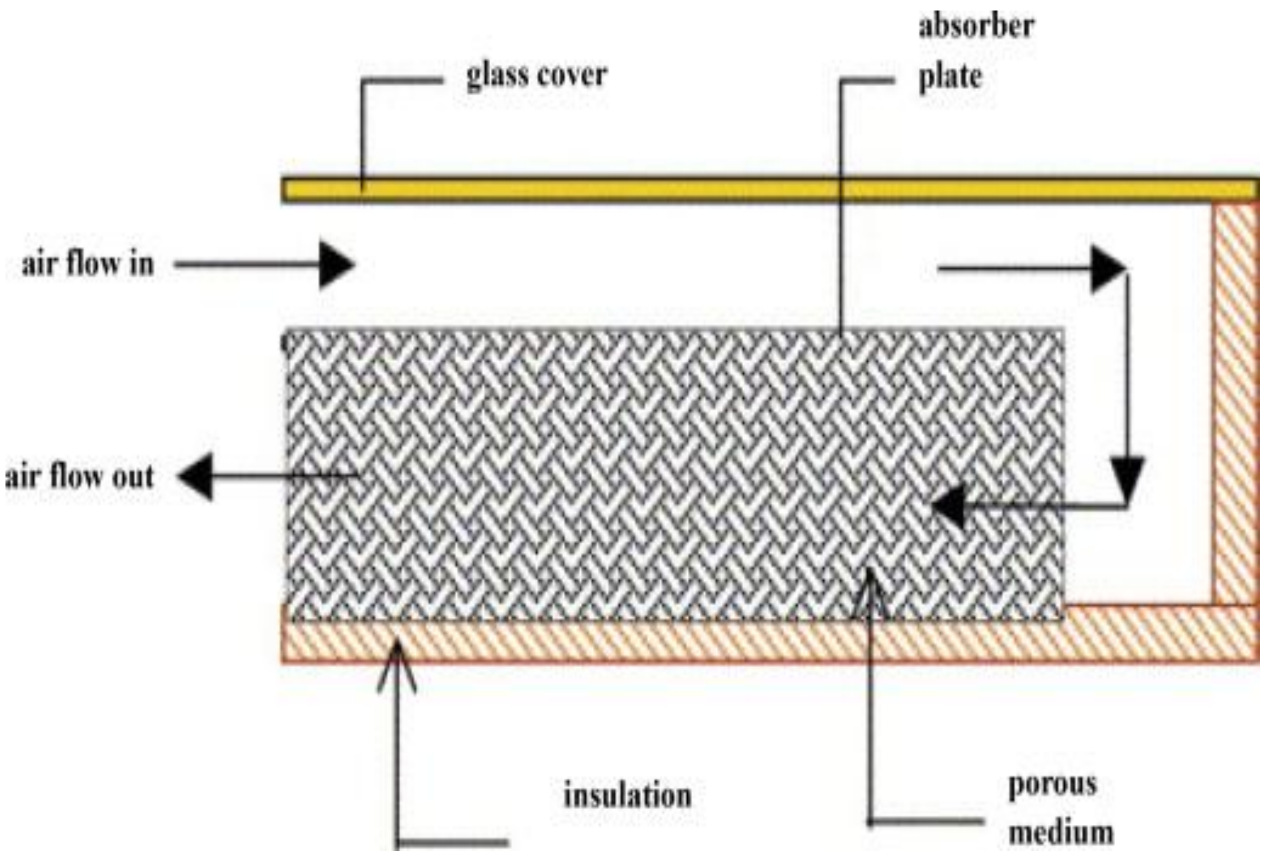
Flat plat collector



- In solar air heater, flat plat collectors are the best heat transferring devices. But the effectiveness of these collectors is very low because of lack of technology. Solar assisted heated air is successfully used for drying applications and space heating under controlled conditions.

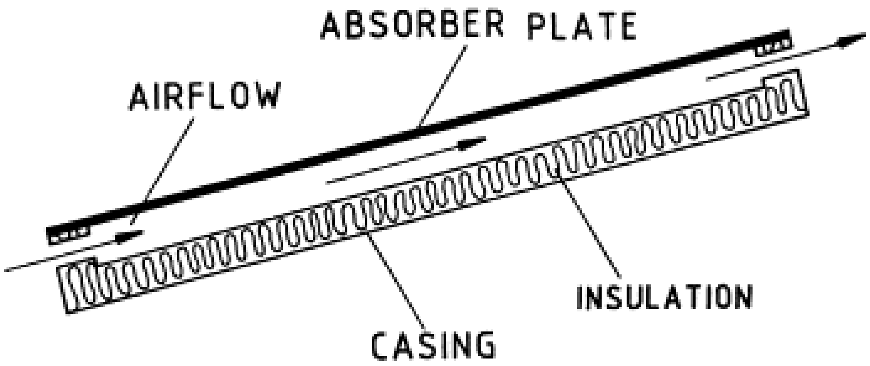
➢ From the solar flat plate air heater the hot air is transferred to a dryer chamber.

➢conventional dryer or to the combined heater and drying chamber directly Hence, solar assisted air heaters are cheaper and reliable.



[Fig. Double air pass solar heater]

- Non-Porous Bed Absorber:



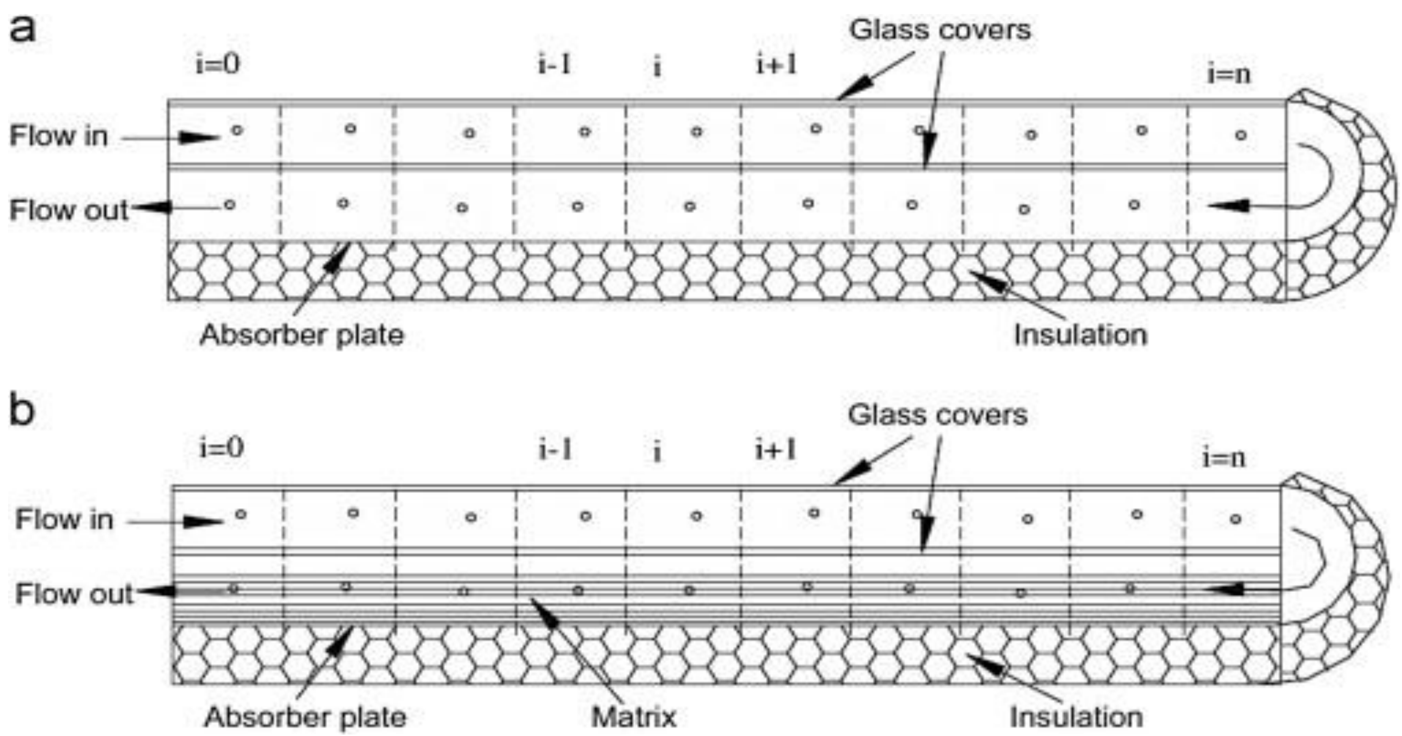
[Fig. Non porous bed absorber]

- In a simple flat plate air collector, commonly known as non-porous absorbers, the air stream flow through the absorber plate without any obstruction.
- An analysis of black painted solar air collectors of conventional design in which the air flows below the absorber plate has been made.

- Porous Bed Absorber:

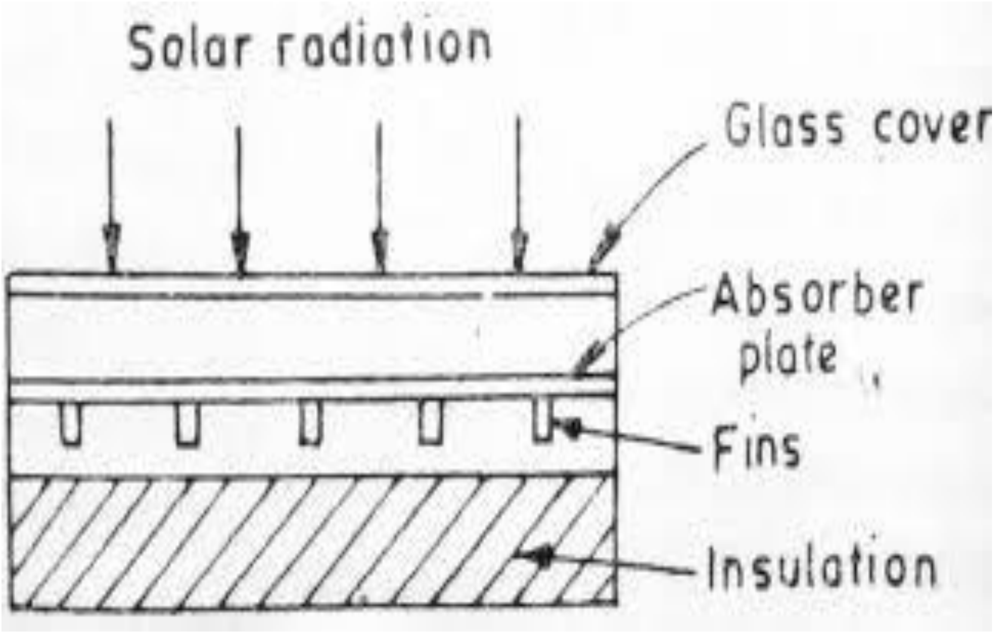
➢ In the porous bed air heater, the matrix material is arranged and the back absorber plate is eliminated.

➢ A single glazed porous bed collector with a reflecting honeycomb, extending above the porous bed to just under the glass cover have theoretically examined



[Fig. porous bed absorber]

Finned absorber:



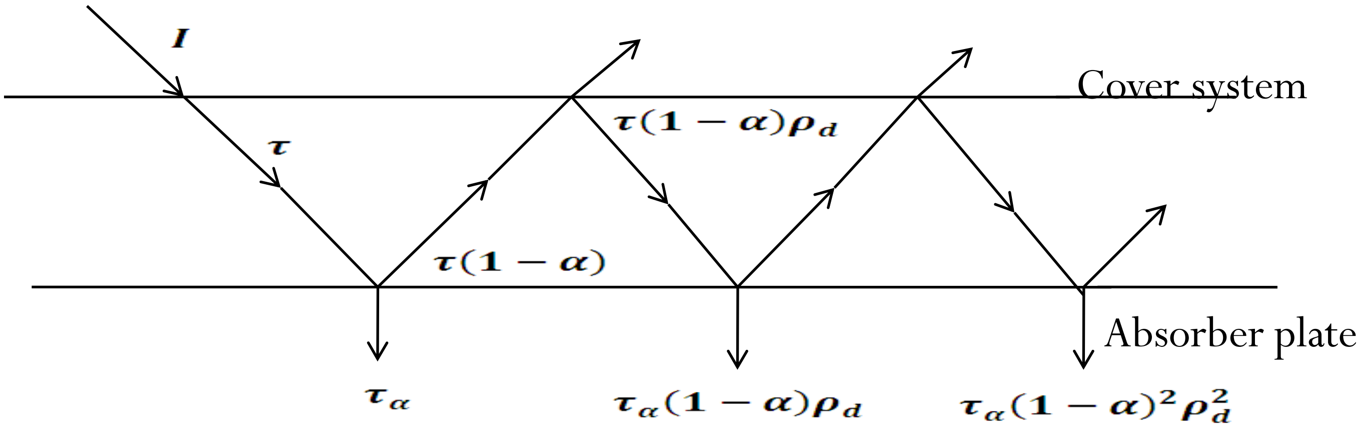
[Fig. Finned type absorber]

- The finned plate absorber increases the heat transfer area over a simple flat plate absorber of the same capacity.
- Good design of a finned absorber can increase the heat transfer rate.

LITERATURE REVIEW

- Transmissivity-absorptivity product[2].

➢ The Transmissivity-absorptivity product is define as the ratio of flux absorbed in absorber plate to the flux incident on the cover system.



➢ Net fraction absorbed = $\dfrac{\tau_\alpha}{1-(1-\alpha)\rho_d}$

$$\rho_d = \tau_a(1-\tau_r)$$

$\rho_d = diffuse\ reflectivity\ of\ the\ cover\ plate.$

LITERATURE REVIEW cont….

The analysis is due to whiller and proceeds alongs lines identically to those adopted for liquid flat collector.
Consider the plate width L_2 and thickness dx at distance x from inlet, then write down below equation. Here air mass flow rate the mean temp. of absorber plate and below t_{pm} and t_{bm} respectively and vibration is negelated and side loss is can be negelated.

- For absorber plate[1]-

$$SL_2dx = U_tL_2dx\left(T_{pm} - T_a\right) + h_{fp}L_2dx\left(T_{pm} - T_f\right) + \frac{\sigma L_2 dx}{\left(\frac{1}{\epsilon_p} + \frac{1}{\epsilon_b} - 1\right)}\left(T_{pm}^4 - T_{bm}^4\right)$$

- For bottom plate[1]-

$$\frac{\sigma L_2 dx}{\left(\frac{1}{\epsilon_p} + \frac{1}{\epsilon_b} - 1\right)}\left(T_{pm}^4 - T_{bm}^4\right) = h_{fp}L_2dx\left(T_{bm} - T_f\right) + U_bL_2dx\left(T_{bm} - T_a\right)$$

- Radiative heat transfer co-efficient[1].

$$h_r = \frac{4\sigma T_{av}^3}{\left(\frac{1}{\epsilon_p} + \frac{1}{\epsilon_b} - 1\right)}$$

,

LITERATURE REVIEW cont….

Here,

$$T_{av} = (T_{pm} + T_{bm})/2$$

Effective heat transfer co-efficient[1]-

$$h_e = \left[h_{fp} + \frac{h_r h_{fb}}{h_r + h_{fb}}\right]$$

Collector efficiency factor[1]-

$$F' = \left(1 + \frac{U_l}{h_e}\right)^{-1}$$

LITERATURE REVIEW cont….

We know the value convective heat transfer coefficient to heated air. The situation corresponds to one of the turbulent flow with one of the long sides heated and the other insulated. It can be considered to be fully developed to be fully developed if the length to-equivalent diameter ratio exceeds value of about 30.

- Collector heat removal factor[1].

$$F_R = \frac{\dot{m}C_p}{U_l A_p}\left[1 - exp\left\{-\frac{F' U_l A_p}{\dot{m}C_p}\right\}\right]$$

- Nusselt number for turbulent flow[1]-

$$N_u = 0.0158 R_e^{0.8}$$

- Equivalent diameter[1].

$$d_e = \frac{4 \times cross\ sectional\ area\ of\ the\ duct}{wetted\ perimeter}$$

- Blesius equation [1].

$$f = 0.079 R_e^{-0.25}$$

$u_l = overall\ loss\ coefficient$

$\tau_\alpha = net\ fraction\ absorbed$

$A_p = area\ of\ absorber\ plat$

$\alpha = angle\ of\ incident\ radiation$

$\varepsilon_b = emissivity\ of\ the\ bottom\ plate\ surface$

$S = flux\ absorbed\ in\ absorber\ plate$

$U_t = top\ loss\ coefficient\ based\ on\ tempertature\ difference$

$U_b = bottom\ loss\ coefficient\ based\ on\ tempertature\ difference$

$h_{fp} = convective\ heat\ transfer\ coefficient\ between\ the\ absorber\ plate\ and\ air\ steam$

$h_{fb} = convective\ heat\ transfer\ coefficient\ between\ the\ bottom\ plate\ and\ air\ steam$

$\varepsilon_p = emissivity\ of\ the\ absorber\ plate\ surface$

$h_r = radiative\ heat\ transfer\ coefficient$

$h_e = effective\ heat\ transfer\ coefficient$

$F_R = collector\ heat - removal\ factor$

$n_u = nusselt\ number$

$f' = collector\ efficiency$

CALCULATION

Flat type double pass natural convection air heater :-

The required data are given below :

Material	Glass
Number of cover	2
Thickness of each cover	4mm
Refractive index of Glass relative to air(n)	1.52mm
Extinction co-efficient of glass(k)	15 m^{-1}
Length of the collector	1.1m
Width of the collector	1.1m
Length of the absorber plate	1m
Width of the absorber plate	1m
Spacing between absorber Plate and bottom plate	15mm
Air flow rate()	200kg/h
Air inlet temperature	50 c
Ambient temperature	20 c
Solar flux incident on the collector face(	950 w/m^2
Transmissitivity – absorptivity of collector	0.936
Top loss co-efficient	6.2 w/m^2
Bottom loss co-efficient	0.8 w/m^2

Solution:-

- Neglect the heat loss from the sides. The property of the air are below.

$$\rho = 1.077 kg/m^3$$

$$C_p = 1.005 \frac{kj}{kg}$$

$$\mu = 19.85 \times 10^{-6} N - \frac{s}{m^2 K}$$

$$K = 0.0287 \, W/m$$

$$T_{fm} = 55°C$$

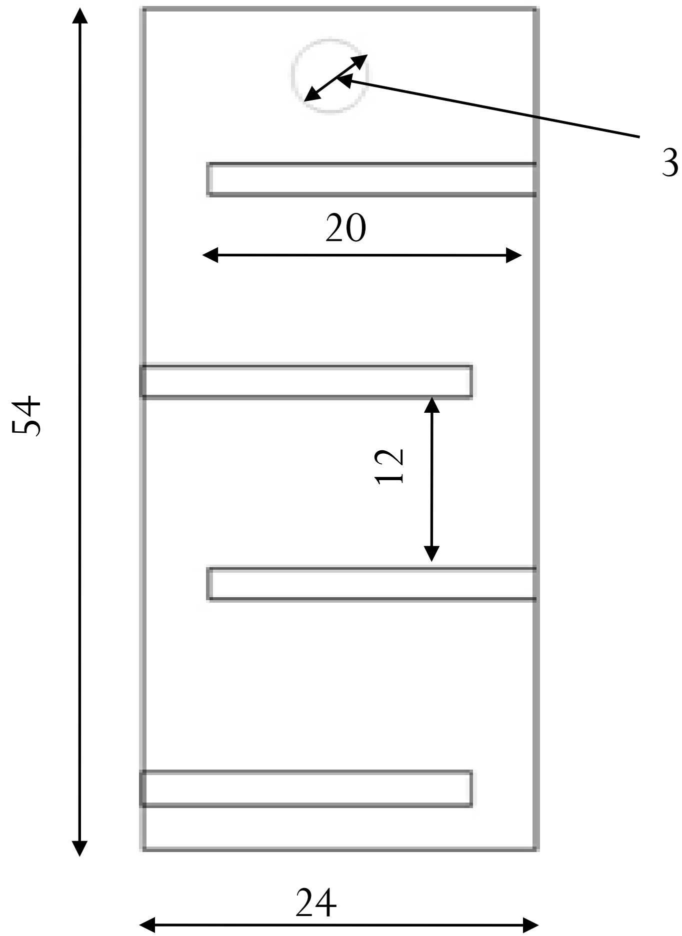
$$h_r = 7.24 \, W/m^2 k$$

$$h_e = 19.97 \, W/m^2 k$$

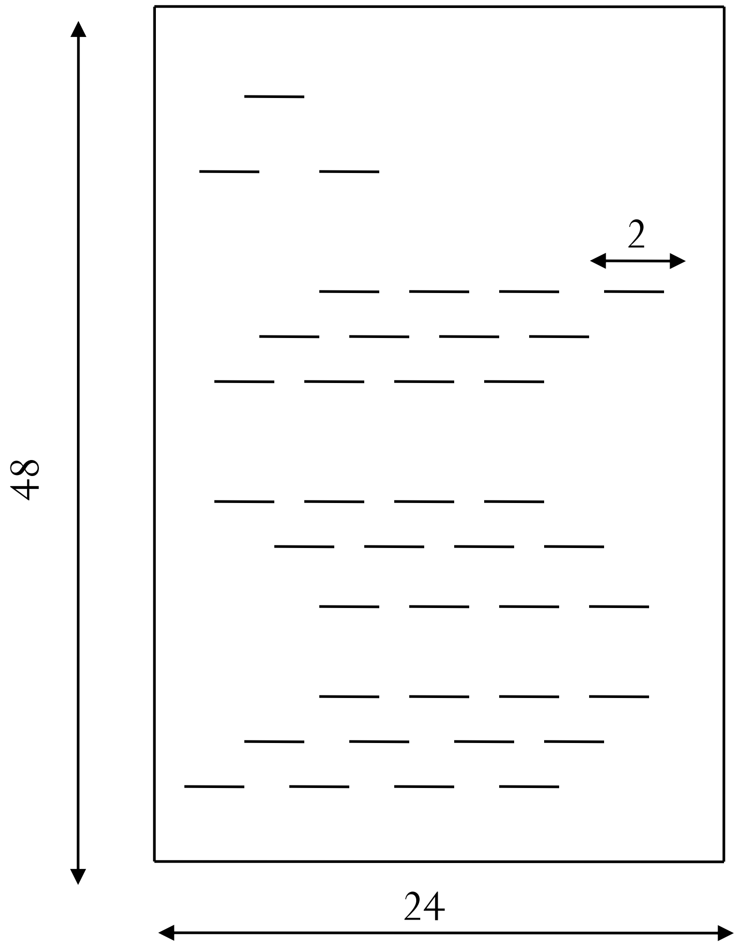
$$F_r = 0.675$$

$$q_u = 458.46 \, w$$

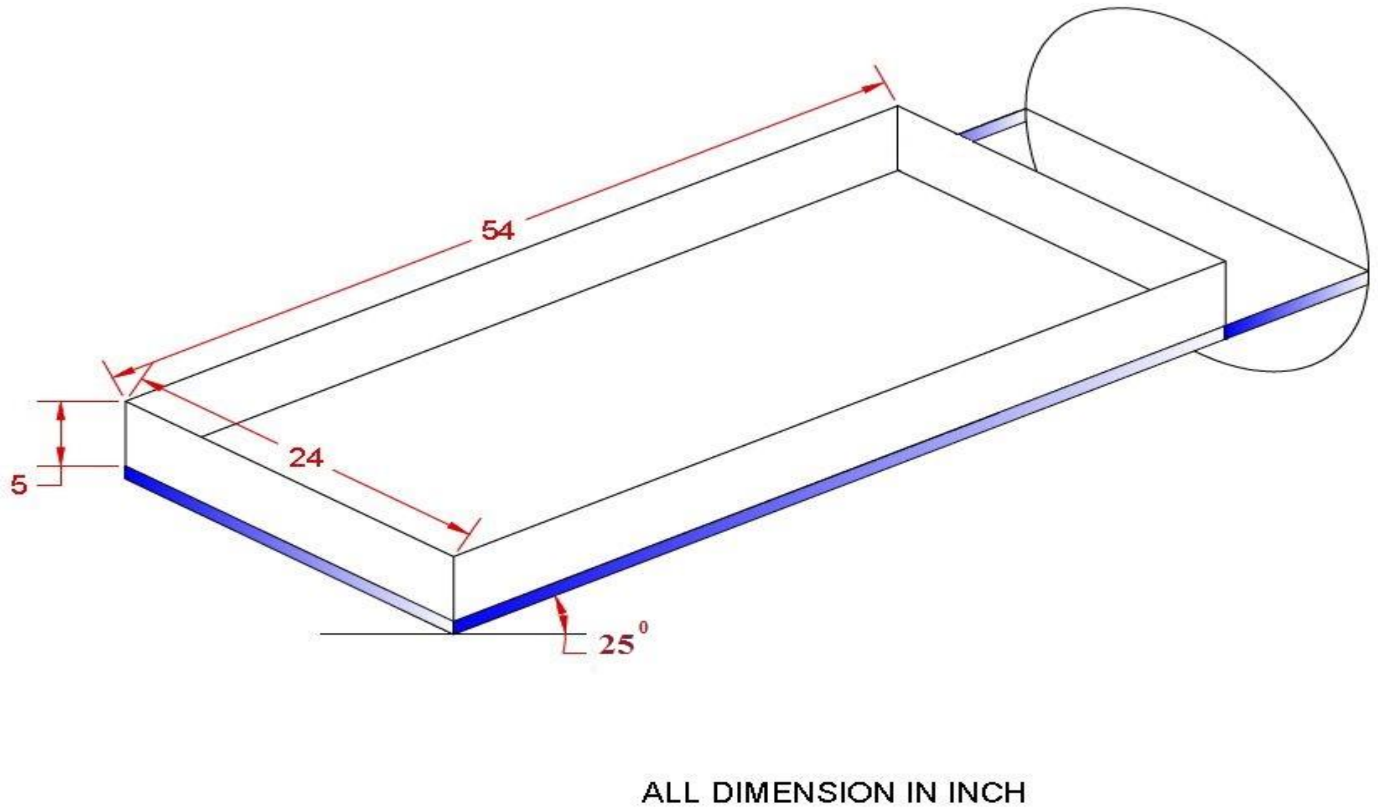
$$\eta = 39.88 \, \%$$



(Fig. diagram of wooden box)



(Fig.Absorber Plate)



(Fig. diagram of solar dryer)

DESCRIPTION

- Wooden box –

  we used the 1372 x 610 x 127 mm wooden material for wooden box and 455 x 50 mm wooden block is used for make a partition to resist a flowing air.

- Absorber Plate –

  we used the 1220 x 610 x 2 mm G.I plate as a absorber plate. The 50 x 15 mm size of fins are attached to absorber plate.

- FAN –



We used the 12v and 18000rpm fan. Velocity of fan is 5m/s for 75mm diameter circular duct which induces the air from solar air heater and blow into drying chamber.

- Glass cover –

We used the 1372 x 610 x 127 mm simple glass material. Aluminuim foil sheets were glued to masonite and used as moisture barrier; prevent moisture from masonite and to reflect incident solar radiations to absorber from sides. The distance between glass cover and absorber plate is kept 51mm.

- Chamber –

A natural convection solar dryer of a box- type (cabinet) was designed and constructed. The constructed dryer (cabinet-type) consisted of drying chamber and solar collector combined it two unit. The fruit like potato chips, banana chips can be dried within less time.

20th April,2014 Angle - 20

20th April,2014 Angle – (-7)

20th April,2014 Angle - 0

(Fig . Whole assemble of oscillating solar dryer)

Temperature indicator :-

(Fig. temperature indicator)

TABLE: DATA OF SOLAR DRYER WITHOUT OSCILLATION ON THE DAY OF 13TH APRIL,2014.

Sr. no	TIME	Air(Inlet) (c)	Air(Outlet) (c)	Δt (c)	t.avg (c)	M (kg/s)	Heat gain (kw)	Qs (kw)	(%)
1	10:00 am	38.4	62.1	23.7	50.25	0.02404	0.572589	1.1295	50.69402
2	10:30 am	40.2	65.9	25.7	53.05	0.023907	0.617488	1.1295	54.66912
3	11:00 am	37.2	65.3	28.1	51.25	0.023819	0.672658	1.1295	59.55364
4	11.30 am	39.2	67.8	28.6	53.5	0.023819	0.684627	1.1295	60.61331
5	12:00 am	39.3	68.1	29.5	54.05	0.023731	0.703554	1.1295	62.28895
6	12:30 pm	40.2	69.1	28.9	54.65	0.023731	0.689244	1.1295	61.02206
7	01:00 pm	40.4	69.0	28.6	54.7	0.023731	0.682089	1.1295	60.38861
8	01:30 pm	41.0	68.3	27.3	54.65	0.023731	0.651085	1.1295	57.64367
9	02:00 pm	42.4	69.5	27.1	55.95	0.023642	0.643911	1.1295	57.00846
10	02:30 pm	42.8	67.2	24.4	55	0.023642	0.579757	1.1295	51.32865
11	03:00 pm	42.3	64.8	22.5	53.55	0.023731	0.536609	1.1295	47.50852
12	03:30 pm	40.2	62.5	20.6	52.5	0.023819	0.493123	1.1295	43.65854
13	04:00 pm	41.1	61.3	20.2	51.2	0.023819	0.483548	1.1295	42.8108
14	04:30 pm	40.5	59.9	19.4	50.2	0.023907	0.466119	1.1295	41.26774
15	05:00 pm	40.1	58.7	18.6	49.4	0.023951	0.447723	1.1295	39.63905

TABLE: DATA OF SOLAR DRYER WITH OSCILLATION ON THE DAY OF 20TH APRIL, 2014

Sr. No.	Time(hours)	Air(inlet) (c)	Air(outlet) (c)	Δt (c)	t.avg (c)	M (kg/s)	Heat gain (kw)	Qs (kw)	(%)	Angle ( )
1	10.00	37.9	65.1	27.2	51.5	0.02404	0.657149	1.1295	58.18048	-15
2	10.30	40	66.2	26.2	53.1	0.023907	0.629501	1.1295	55.73273	-11
3	11.00	39.1	68.5	29.4	53.8	0.023819	0.703778	1.1295	62.30879	-7
4	11.30	38.7	68.9	30.2	53.8	0.023819	0.722928	1.1295	64.00427	-3
5	12.00	39.4	69.6	30.2	54.5	0.023731	0.720248	1.1295	63.76699	0
6	12.30	40.1	69.8	29.7	54.95	0.023731	0.708324	1.1295	62.71125	5
7	13.00	40.6	69.5	28.9	55.05	0.023731	0.689244	1.1295	61.02206	8
8	13.30	40.9	69.7	28.8	55.3	0.023731	0.686859	1.1295	60.81091	12
9	14.00	42.3	70.1	27.8	56.2	0.023642	0.660543	1.1295	58.481	15
10	14.30	42.9	68.7	25.8	55.8	0.023642	0.613022	1.1295	54.27374	17
11	15.00	42.4	68.2	25.8	55.3	0.023731	0.615311	1.1295	54.47644	19
12	15.30	41.1	67.5	26.4	54.3	0.023819	0.631964	1.1295	55.95075	20
13	16.00	41.3	66.9	25.6	54.1	0.023819	0.612813	1.1295	54.25527	23
14	16.30	40.2	65.2	25	52.7	0.023907	0.600669	1.1295	53.18008	26
15	17.00	39.2	64.4	25.2	51.8	0.023951	0.606593	1.1295	53.70452	31

Calculation of actual Efficiency :-

Time (t) : 12.00 noon
Density (: 1.075kg/m^3
Diameter (d) : 0.075m
Specific heat : 1.005
Temperature difference(Δt) : 29.5 $^\circ$c

$$\dot{m} = A \times C \times \rho = 1.075 \times \frac{\pi}{4} d^2 \times 5$$
$$\dot{m} = 0.023731$$

Now,

Heat gain, $Q = \dot{m} \times c_p \times \Delta t = 0.0237 \times 1.005 \times 30.2$

$$Q = 0.7203$$

Here,

Solar radiation coming on earth is 1350 kw/m^2. [1] . so, solar radiation received by collector plate is, = 1.350 Area of glass.

Solar Radiation in collector plate = 1.1295 kw

So,

Efficiency,

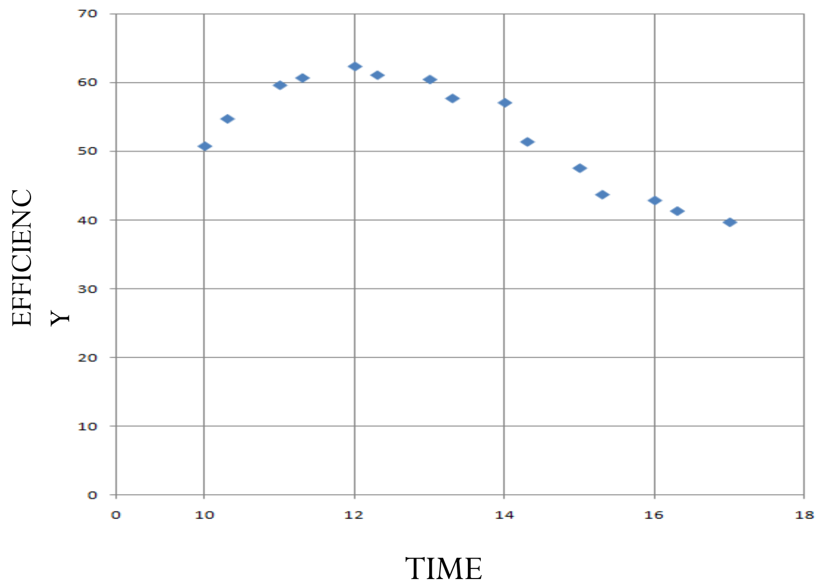
$$\eta = \frac{heat\ gain}{\text{solar radiation in collector plate}}$$

$$= \frac{0.7203}{1.1295}$$

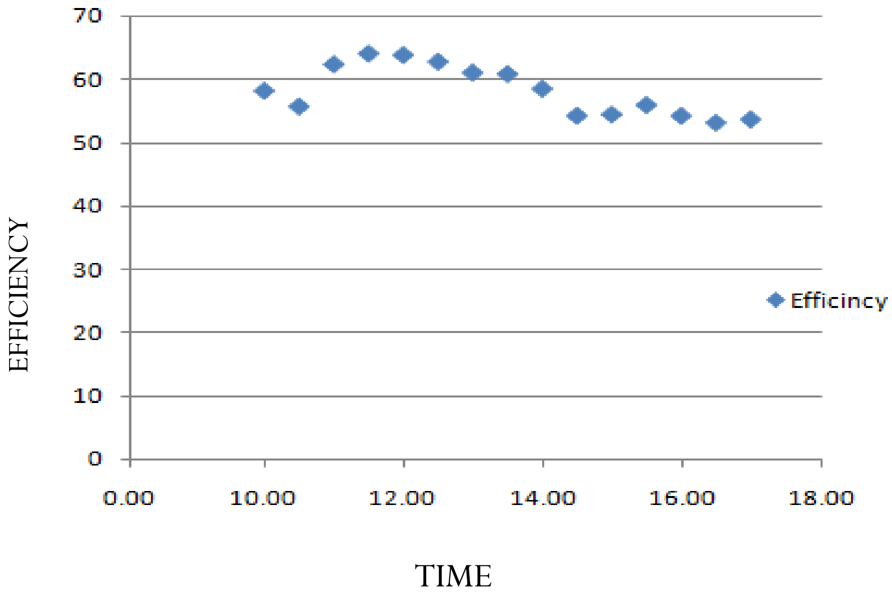
$$= 0.6377$$

$$= 63.77\%$$

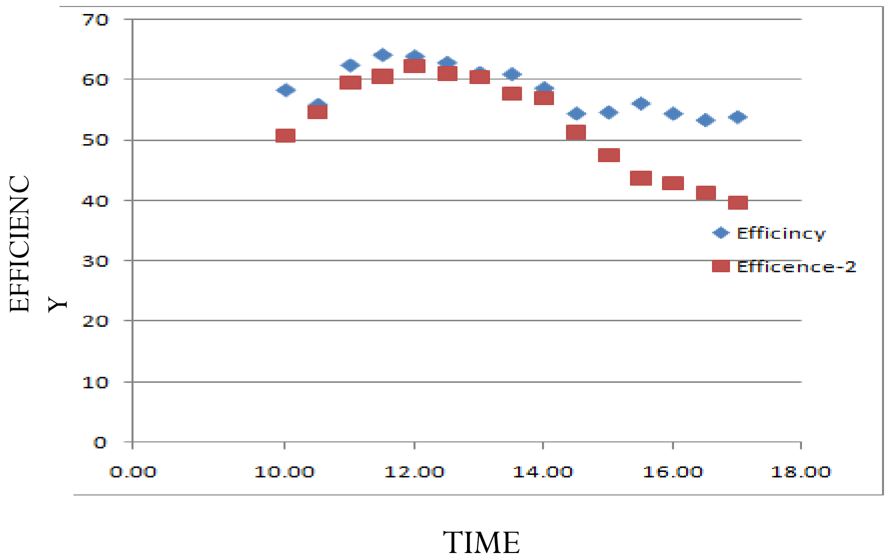
• GRAPH :-



Graph : without oscillation bed



Graph : with oscillation bed



Graph : comparison of both efficiency

CONCLUSION

- As we know the solar energy is not providing same amount of heat between winter and summer. So it is very difficult to dry some food product like chilies, chips of the potatoes etc. even in summer it require a lot space and gain of its heat when we have to do it by human effort.

- Here double pass, finned, oscillating (manually) type flat plate collector bed is prepared. The airs pass through upper portion first then it is induced by fan and to make the worm air pass through its lower portion in which it is finned. Then it to finally supplied to “dryer chamber”.

- For one pass natural fixed bed solar air heater, theoretical efficiency is 39.88 % and for one pass forced air fixed bed solar air heater, theoretical efficiency is 44.26 %.

- The bed is at 25 angle with horizontal plane. The inlet air and outlet air temperature are taken on the day 13th April, 2014. With zero angles(without oscillation) and the maximum efficiency of the collector plate is 62.28% , average efficiency is 52.67%.

- Then on the day of 20th April, 2014. The bed is manually operated and to take the sun and made to face sun perpendicularly after every half and hour. The maximum efficiency is 63.77%, average efficiency 58.19%.

- we can get high efficiency throughout the day.

FUTURE WORK

- The oscillation of the flat plate collector and to track the sun from morning to evening can be atomized according to sun's zenith angle.
- The losses of hot air must be reduced at the glass sheet due to leakage of hot air and incoming of fresh air from surrounding through joints.
- The insulation at the sides and bottom of box could be improved to reduce heat losses.

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THANK YOU