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ISSN:2348-2079

FEB-2016

International Journal of Intellectual Advancements and Research in Engineering Computations

EXPERIMENTAL ANALYSIS OF SHEET METAL ROOF AS SOLAR COLLECTOR FOR DRYING APPLICATIONS

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ABSTRACT

The technology of solar energy power conversion has gained its importance in industries, agriculture as well as for domestic purpose. It therefore important for technician and an engineer to have good knowledge of solar power, its generation and its utilization. The solar energy received in the form of solar radiation(diffuse or beam radiation) is converted by direct or indirect energy conversions method. In this project, solar power is absorbed in sheet roof plate which is used for drying of vegetable and fruits. An forced convection solar drier and tested its performance for drying chili under the metrological conditions. The system consists of a sheet metal roof solar collectors used for air heating with a drying chamber, and a centrifugal vane blower. Drying experiments have been performed at an constant air flow rate.

Keywords*:* Solar dryer, Forced convection, Sheet metal roof collector.

INTRODUCTION

Basically, the drying implies the partial removal moisture or water from the material. But when fuel fired equipment is used in the process the term dehydration is often applied. Sun has the potential to become the primary source of energy in every field of applications. Presently, solar energy is emerging the source of energy and solar drying is one of its important applications. Solar drying is frequently confused with sun drying, which is most wide practiced agricultural drying operation in the world. The direct exposures to sunlight, or more precisely ultraviolet radiation, can greatly the level of nutrients such as vitamins in the dried products. Increasing labor cost, improving quality standards and sometimes uncertain climates lead to the constructions of artificial dryers.

These dryers are capable of providing a high quality product independent of the weather and with a low labor requirement. They are not, however intrinsically suitable for the small scale former or the majority of agro industries in developing countries. One of the common method suitable for the farms of developing countries is solar drying. This method has several advantages such has less spoilage and less micro- biological infestation, thus leading to improved and more consistent quality. Solar drying can also be a feasible alternative to those natural convection dryers that use wood or agricultural waste products as fuel. The saving of wood would probably be the main attraction of solar dryers.

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TYPES OF SOLAR DRYER

Direct Type Dryers

In direct or natural convection type dryers, the agricultural product is placed in shallow layers in a blackened enclosure with a transparent cover. The solar radiations are directly absorbed by the product itself. The food product is heated up and the moisture from the product evaporates and goes out by the natural convection/circulation.

Indirect solar dryer

In this type of dryer, the produce is placed on trays inside an opaque chamber to which is attached an air type solar collector. The sun does not shine directly the material to be instead the air heated in solar collector is ducted to the drying chamber for the dehydration. Air circulation can be by natural convection however it is often forced by blowers. These dryers result in higher temperature than the cabinet dryers or sun drying and can produce higher quality products.

Forced Circulation Type Dryers

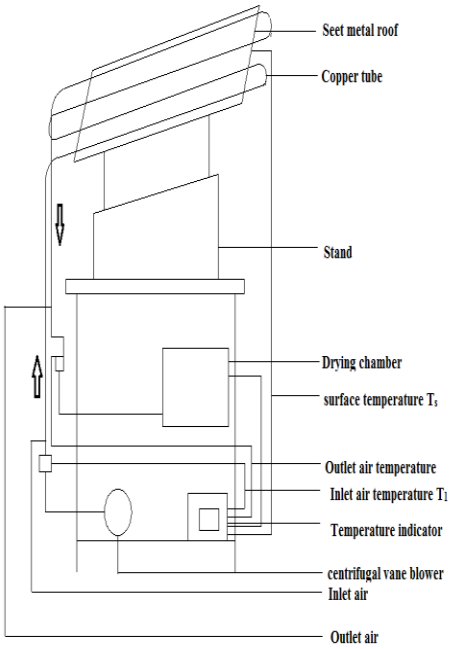
Several storage systems are proposed but the most preferred one is the rock bed storage system which stores the heat in the form of sensible heat and performs the dual function of storing the heat and that of a heat exchanger. A hybrid solar dryer (solar assisted) was developed at Fresno, California for drying large amount of fruits and vegetables.

EXPERIMENTAL SETUP

1. Sheet metal roof
2. Centrifugal vane blower

Fig No: Metal Roof Solar Energy Collector

Arrangement of Experimental Setup



MASS FLOW RATE OF AIR CALCULATION

Area the collector surface = l*b=1.1*0.62

= 0.682m^2.

Area of the copper tube (A_c)=1.168*$10^4$$m^2$.

Inlet pipe outer diameter =0.025m

Inlet pipe inner diameter =0.02m

Total inlet pipe diameter $=d_1+ d_2/2$

$=0.0225m^2$

Area of the inlet pipe $=\pi d^2/4$

$=39760*10^{-4}m^2$.

Discharge Of Air At 1:00pm

$Q_1 = c_d a_1 a_2 \sqrt{2gh_a} / \sqrt{(a_1)^2-(a_2)^2}$

a_1 & a_2=area of the inlet& outlet orifice.

$a_1=3.9760*10^4m^2$: $a_2 =7.93*10^{-5}$ m^2.

$h_a =5.5*10^{-3}m$

$Q_1 =0.6*3.9760*10^4*7.93*10^{-5}*\sqrt{2*9.81*5.5} / \sqrt{(0.07935)^2-(3.9760*10^4)^2}$

$=4.9457*10^{-4}m^3/s.$

Velocity of Air

$U = Q_a/A_i=4.9457*10^{-4}/3.9760*10^4$

$= 1.25m/s.$

Discharge of Air At 1:30pm

$Q_1 = c_d a_1 a_2 \sqrt{2gh_a} / \sqrt{(a_1)^2-(a_2)^2}$

a_1 & a_2=area of the inlet& outlet orifice.

$a_1=3.9760*10^4m^2$: $a_2=7.93*10^{-5}$ m^2.

$h_a =0.011m.$

$Q_1 = 2.218*10^{-4}m^3/s$

Velocity of Air

$U = Q_a/A_o=2.218*10^{-4}/3.9760*10^{-4}$

$=0.55m/s.$

Volumetric Flow Rate

$Q_2 = A_1*V1$

$V_1 =Q/A_1$; $V_2 = Q/A_2$

A_1 =area of pipe-m^2

A_2 =area of orifice-m^2

d_1 =dia of pipe-m

d_2 = dia of orifice hole-m

$\rho =1.093kg/m^3.$

$Q_2 = cA_2\sqrt{2(P_1-P_2)/\rho}$

$C = C_d/\sqrt{1-(\beta)^4}$

$\beta =d_2/d_1$

$C = 0.6/\sqrt{1-(0.01005/0.0225)^4}$

$C =0.6123$

$Q_2 = 0.6123*7.935*10^{-5}*\sqrt{2(39.39-37.01)/1.093}$

$Q_2 = 1.01328*10^{-4}m^3/s.$

Mass Flow Rate of Air

$\dot{m}_a = \rho*A*U$

$= 1.093*\pi(0.0122)^2/4*(1.25)$

$=0.0159kg/s.$

EFFICIENCY CALCULATION FOR THE COLLECTOR AT MAXIMUM TEMPERATURE

Internal flow through copper tube

Bulk mean temperature T_m

$=T_i+T_o/2 =56.3+40/2$

$T_m =48.15^{\circ}c$

From HMT data book, PageNo.33

$\rho =1.093kg/m^3$

$\upsilon =17.95*10^{-6}m^2/s$

$Pr =0.698$

$C_P =1005J/kgk$

$k =0.02826w/mk$

$R_e =U D/\upsilon$

$=1.25*0.0127/(17.95*10^{-6}).$

$=844.401*10^1>2300$

Flow is turbulent.

Internal Flow

$N_u =0.023(Re)^{0.8}(pr)^n$

$=0.023(8884)^{0.8}(0.698)^{0.4}$

$N_u =176.16$

$N_u =h*D/K$

$176.16 =h*0.0127/0.02826$

Heat Transfer Coefficient h $=392w/m^2k.$

Collector efficiency factor

$F' =1/wu_l[1/u_l(\omega-d_o)\phi+d_o]+1/\Pi d_i h]$

$=1/0.4136[6.593+0.09831]$

$F' =0.36$

Heat removal factor

$F_R = \dot{m}C_P/U_lA_P[1-\exp[-F' U_lA_P/\dot{m}C_P]]$

$=64.34/4*[1-e^{[-4*0.36/64.34]}]$

$F_R =0.356$

Useful heat gain

q_u = $F_R A_P[S-U_l(T_0-T_a)$

=0.356*0.682[503-4(56.3-40)

=145.24W

Collector efficiency

η_i = $q_u/A_P I_T$ =145.24/0.682*670.23

=0.3177*100

=31.77%

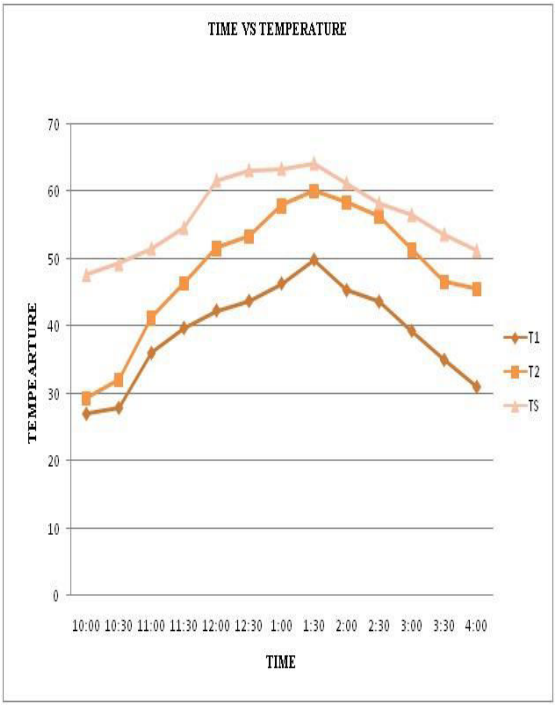
RESULTS AND DISCUSSIONS

The efficiency is calculated and useful heat gain also calculated. The above graph gives detail about the efficiency that calculated by taking the inlet and outlet temperature. As discussed earlier the efficiency rate at the starting stage that is at 10.00 am is low compared with the other timings is shown in the above graph due to the less temperature and the copper tube mounted on the surface of the metal roof. The efficiency at the time from 12.00pm to 1.30pm is some what higher than efficiency that calculated at other times reduce outlet temperature and also efficiency also will get reduced. Finally the efficiency obtained is 31.77%.

Day 1

TIME	T_1°c	T_2°c	T_S°c
10:00	27	29.4	47.7
10:30	27.9	32.1	49.3
11:00	36	41.3	51.6
11:30	39.7	46.4	54.7
12:00	42.3	51.6	61.7
12:30	43.7	53.4	63.2
1:00	46.3	57.9	63.4
1:30	49.8	60.1	64.2
2.00	45.3	58.5	61.3
2:30	43.6	56.4	58.3
3:00	39.3	51.4	56.6
3:30	35	46.7	53.7
4:00	31	45.6	51.3

Graph of time vs. temperature

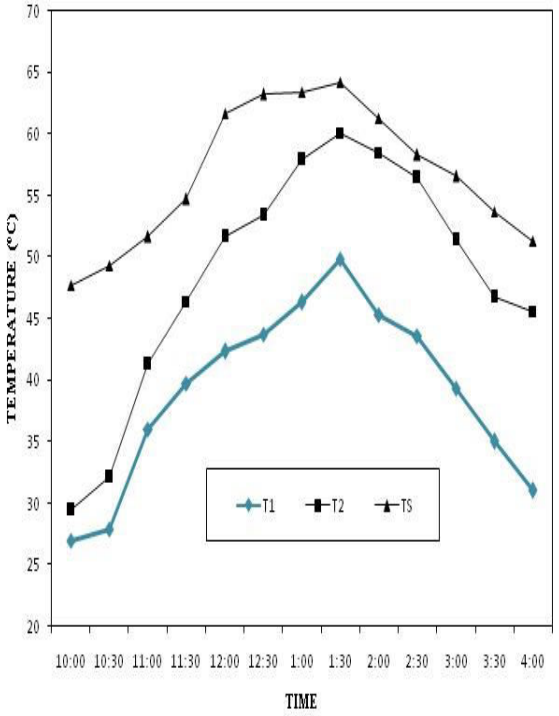


Day 2

Table: Time vs. temperature

TIME	T_1°c	T_2°c	T_S°c
10:00	27	29.4	47.3
10:30	29.3	31.7	50.5
11:00	31.5	33.1	53
11:30	31.1	36	56.1
12:00	31.7	41.3	59.7
12:30	35.4	47.9	63.4
1:00	39.3	54.7	64.3
1:30	40	56.3	66.7
2.00	38.7	57.4	64.89
2:30	37.4	54.3	61.7
3:00	35.4	52.4	58.7
3:30	34.32	50.3	56.3
4:00	31.2	48.7	52.4

Graph of time vs. temperature



CONCLUSION

The metal roof solar collector was fabricated. It was tested drying vegetables. The performance of solar dryer was computed. In renewable energy sources solar energy is most appropriate for drying system. This energy allows independent system to be constructed and a thermal conversion mode which necessitates a simple technology which is adapted to the plural for crop drying applications. These system are all based on the metal roof solar air collector.

SCOPE FOR FUTURE WORK

The efficiency of solar collector can be increased by increasing the collecting area. We can replace aluminum sheet instead of metal roof for increasing efficiency of drying. We can also replace the GI piped instead of copper tube. And also we can use the phase change material for storage of heat energy during night time. And the other types of solar absorber plates were also to be replaced for the experiments.

REFERENCES

[1]. Bala BK, Mondol MRA, Biswas BK, Chowdury BL, Janjai S. Solar drying of pineapple using solar tunneldrier. Renewable Energy 2003;28:183–90.

[2]. Choudhury, C., Anderson , S.L., Rekstad, J., "A solar air heater for low temperature applications" , solar energy, Vol. 40, pp. 335-344, 1988.

[3]. Gupta, D., Solanki, s.c., saini, J.s., " Thermo hydraulic performance of solar air heaters with roughened absorber plates" , solar energy, Vol. 61, pp.33-42, 1997.

[4]. Jannot Y, Coulibaly Y. The "evaporative capacity as a performance" index for solar-drier air heater.J. Solar Energy 1998;63(6):387–91.

[5]. Kolb A, Winter ERF, Viskanta R. Experimental studies on a solar air collector with metal matrixabsorber. J. Solar Energy 1999;65(2):91–8.

[6]. Mohamad , A.A., "High efficiency solar air heater", solar energy Vol. 60, pp.71-76, 1997.

[7]. Niles PW, Carnegie EG, Pohl JG, Cherne JM. Design and performance of an air collector for industrial crop dehydration. Solar Energy 1978;20:19–23.

[8]. Schirmer P, Janjai S, Esper A, Smitabhindu R, Muhlbauer W. Experimental investigation of theperformance of the solar tunnel dryer for drying bananas. Renewable Energy 1996;7(2):119–29.

[9]. S.P.Sukhatme "principles of thermal collection and storage", Solar energy, pp.58-110.1989.

[10]. Yadav V, Moon CG. Fabric-drying process in domestic dryers. 2008;85(2–3):143–58.

[11]. Soponronnarit S, Assayo M, Rakwichian W. Performance of a solar banana dryer. RERIC Int Energy J1991;13:71–9.