

“PERFORMANCE AND EVALUATION OF MODIFIED SOLAR DRYER FOR BATCH OF PRODUCT”

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ABSTRACT: The objective of this paper is to design, develop and evaluate performance of an Indirect-Type Passive pop can solar dryer in a passive mode using thermal energy storage and without thermal energy storage for the drying of product. Drying is one of the oldest methods using solar energy where the product such as vegetables, fruits, fish, and meat to be dried exposed directly to the sun. This method has many disadvantages such as spoilt products due to rain, wind, dust, insect infestation, animal attack and fungi. Foods should be dried rapidly, but the speed of drying will cause the outside becomes hard before the moisture inside has a chance to evaporate and it will affect the quality of dried product due to over drying. Food products, especially fruits and vegetables require hot air in the temperature range of 45–75 °C for safe drying.. This design was employed and has compared with the performance testing through parameters such as temperature, moisture content. It was shown that the use of pop can solar dryer reduced the drying time significantly and essentially provides better product quality compared with conventional drying method. The effect of temperature to moisture contents against time and rate of drying are studied in this research.

Keywords: Air-heating, Pop can collector, Drying chamber.

1. INTRODUCTION

This type of solar dryer is inspired by commercial solar air heater which uses recycled aluminium soda cans stacked end to end to create long tubes for the air flow through it with help of fins so that where two cans meet causes turbulence in the air flow and make more air flow in contact with inner surface of cans and therefore take more heat from the cans resulting in increased efficiency.

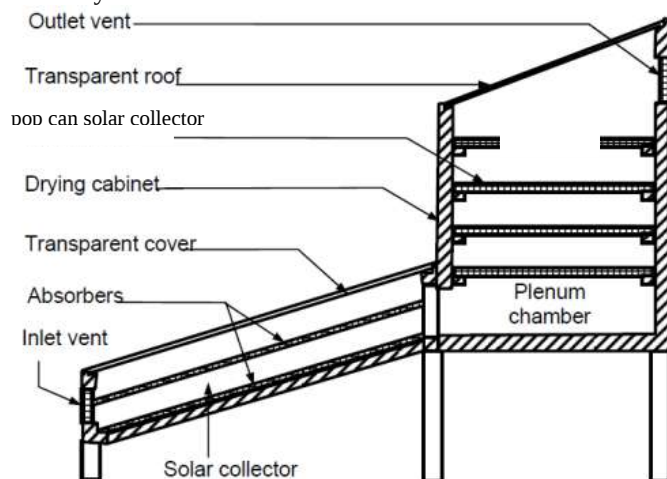


Figure 1: Block diagram Indirect-Type Passive solar dryer

On just about all solar thermal collectors, the sun shines through the glazing, and hits the collector absorber heating it. The air flows through the inlet and over or inside or through the absorber picking up heat as it goes. This heated air then flows out the collector outlet and into the room being heated. The main

differences between air heating collector designs have to do with how the air flows over the absorber.



Figure 2: Actual Indirect-Type Passive pop can solar dryer

In full sun, the incoming solar energy is about 1000 watts per square meter of collector area. Of this 1000 watts/sm, about 10%

is absorbed or reflected by the glazing and never gets to the absorber. Of the remaining solar energy, about 95% is absorbed by the absorber. So, for the 1000 watts/sm that arrive at the collector face, about 850 watts/sm end up actually heating up the absorber. In this sense, proper utilization of solar energy for crop drying can easily be possible by choosing a proper solar dryer.

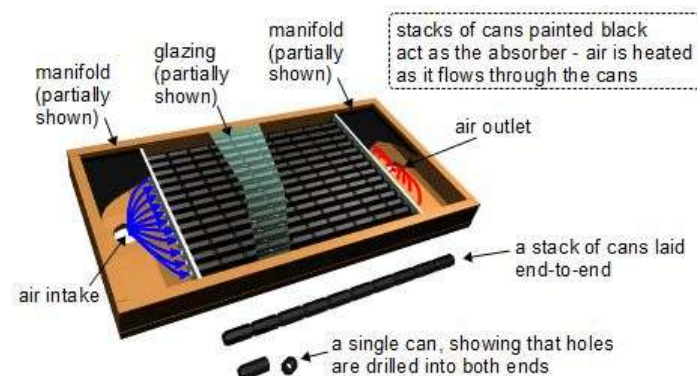


Figure 3: Working mechanism of pop can collector

Solar dryer can raise the ambient temperature to a higher value for effective drying. Several studies have been reported on drying crops and grains (Waewsak J et al,2006). A number of solar dryers have been constructed and designed for different crops in the literature (Forson FK et al,2007).

2. MATERIAL AND METHOD

TABLE 1:PARAMETERS FOR COMPARING DRYERS .

Sn.No	Parameter	Reason For Modification
1	Maintenance and purchase cost of dryers	Extend useful life and effective for chosen foe small/large scale farmer
2	Drying Capacity	How much temp exceeds from existing temp and quantity of product used at same time
3	Range of products	Applicable for single or diffrent products
4	Quality of final product	Final moisture content after drying
5	Adaptability to local condition	Manufacturing and need ,kind in local areas
6	efficiency	Solar/biomass energy used effectively.

The energy balance of the absorber is obtained by equating the total heat gained to the total heat loosed by the heat absorber of the solar collector. Therefore,

$$I_{Ac} = Q_u + Q_{cond} + Q_{conv} + Q_R + Q_p, \quad (1)$$

Where: I = rate of total radiation incident on the absorber's surface (Wm^{-2}); A_c = collector area (m^2); Q_u = rate of useful energy collected by the air (W); Q_{cond} = rate of conduction losses from the absorber (W); Q_{conv} = rate of convective losses from the absorber (W); Q_R = rate of long wave re-radiation from the absorber (W); Q_p = rate of reflection losses from the absorber (W). The three heat loss terms Q_{cond} , Q_{conv} and Q_R

are usually combined into one-term (Q_L), i.e.,

$$Q_L = Q_{cond} + Q_{conv} + Q_R. \quad (2)$$

If τ is the transmittance of the top glazing and IT is the total solar radiation incident on the top surface, therefore,

$$I_{Ac} = \tau IT_{Ac}. \quad (3)$$

The reflected energy from the absorber is given by the expression:

$$Q_p = \rho \tau IT_{Ac}, \quad (4)$$

Where ρ is the reflection coefficient of the absorber. Substitution of Eqs. (2), (3) and (4) in Eq. (1) yields:

$$\tau IT_{Ac} = Q_u + Q_L + \rho \tau IT_{Ac}, \text{ or}$$

$$Q_u = \tau IT_{Ac} (1 - \rho) - Q_L.$$

For an absorber $(1 - \rho) = \alpha$ and hence,

$$Q_u = (\alpha \tau) IT_{Ac} - Q_L, \quad (5)$$

Where α is solar absorbance. Q_L composed of different convection and radiation parts. It is presented in the following form (Sodha et al. 1985):

$$Q_L = UL_{Ac} (T_c - T_a), \quad (6)$$

Where: UL = overall heat transfer coefficient of the absorber ($Wm^{-2}K^{-1}$); T_c = temperature of the collector's absorber (K); T_a = ambient air temperature (K). From Equations (5) and (6) the useful energy gained by the collector is expressed as:

$$Q_u = (\alpha \tau) IT_{Ac} - UL_{Ac} (T_c - T_a). \quad (7)$$

Therefore, the energy per unit area (q_u) of the collector is

$$q_u = (\alpha \tau) IT - UL(T_c - T_a). \quad (8)$$

If the heated air leaving the collector is at collector temperature, the heat gained by the air Q_g is:

$$Q_g = \dot{m}_a C_{pa} (T_c - T_a), \quad (9)$$

Where: $\dot{m}_a$ = mass of air leaving the dryer per unit time ($kg s^{-1}$); C_{pa} = specific heat capacity of air ($kJ kg^{-1} K^{-1}$). The collector heat removal factor, FR , is the quantity that relates the actual useful energy gained of a collector, Eq. (7), to the useful gained by the air, Eq. (9). Therefore,

$$F_R = \frac{\dot{m}_a C_{pa} (T_c - T_a)}{A_c [\alpha \tau I_T - U_L (T_c - T_a)]} \quad (10)$$

OR $Q_g = A_c FR [(\alpha \tau) IT - UL_{Ac} (T_c - T_a)]$. (11) The thermal efficiency of the collector is defined as (Itodo et al. 2002) is given in Eq. (12):

$$\eta_c = \frac{Q_g}{A_c I_T}.$$

Energy Balance Equation for the Drying Process

The total energy required for drying a given quantity of food items can be estimated using the basic energy balance equation for the evaporation of water (Youcef-Ali, et al. 2001; Bolaji 2005):

$$\dot{m}_w L_v = \dot{m}_a C_p (T_1 - T_2), \quad (13)$$

where: L_v = latent heat ($kJ kg^{-1}$) $\dot{m}_w$ = mass of water evaporated from the food item (kg); $\dot{m}_a$ = mass of drying air (kg); T_1 and T_2 = initial and final temperatures of the drying air respectively (K); C_p = Specific heat at constant pressure ($kJ kg^{-1} K^{-1}$). The mass of water evaporated is calculated from Eq. 14:

$$\dot{m}_w = \frac{\dot{m}_i (M_i - M_e)}{100 - M_e}, \quad (14)$$

Where: $\dot{m}_i$ = initial mass of the food item (kg); M_e = equilibrium moisture content (% dry basis); M_i = initial moisture content (% dry basis). Other factors that may enhance quick drying of food

items are: high temperature, high wind speed and low relative humidity.

3. RESULT AND DISCUSSION

Chilli ripe as well as dried is a popular ingredient in Indian food, and chilli is most common spices cultivated in India. It is grown in all parts of country, hills and plain region. Experimental investigation on drying chilli has been compared with different design and shapes of solar dryers. The moisture content of raw chilli is usually in the range of 75-90%, while dried chilli contains about 4-9% of moisture. Chilli required 5-13 days for open sun drying while by solar dryers drying time varied from 12 hrs to 9 days depending on weather conditions and dryer design. The results obtained during the test period revealed that the temperatures inside the dryer and solar collector were much higher than the ambient temperature during most hours of the day-light. The temperature rise inside the drying cabinet was up to 74% for about three hours immediately after 12.00h (noon).

Type of dryer	Moisture(%)		Drying time	Temperature		Full load capacity	efficiency
	Initial	final		ambient	average		
Pop can dryer	85.33	3.89	2 days	29	70.22	5-10 kg	60.51 %
Flat plate dryer	85.33	7.31	9 days	29	55.69	5-10 kg	29.56 %

TABLE 2 : Comparative study of two solar dryers for chilli

The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product.

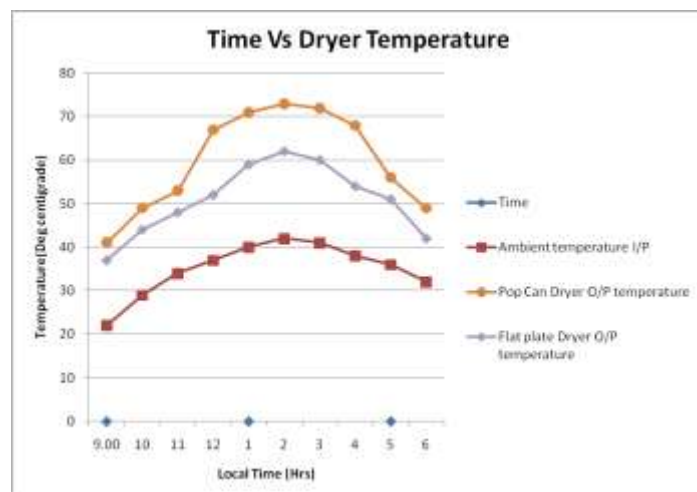


Figure 4: Variation of the temperatures in the pop can and flat solar collector to the ambient temperature.

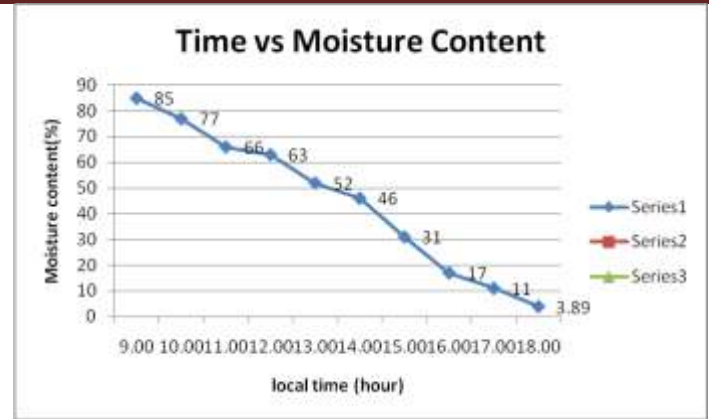


Figure 5: time vs Moisture content for po can collector

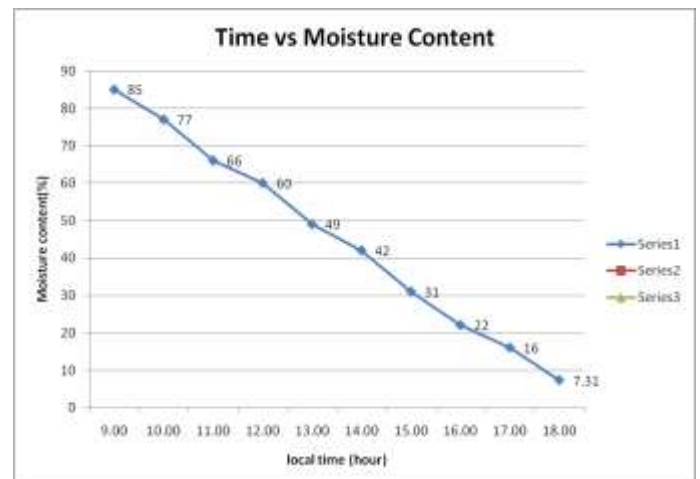


Figure 6: time vs Moisture content for Flat plate collector

4. CONCLUSION

The simple and inexpensive pop can solar dryer was designed and constructed using locally sourced materials which is the modification as far. The hourly variation of the temperatures inside the cabinet and air-heater are much higher than the ambient temperature during the most hours of the day-light. The temperature rise inside the drying cabinet was up to 24oC (74%) for about three hours immediately after 12.00h (noon). The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product. . It was shown that the use of pop can solar dryer reduced the drying time significantly and essentially provide better product quality compared with conventional drying method.

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