

# Experimental Analysis of Solar Air Heater with Broken Ribsabsorber Plate for Fruits Drying Applications

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**ABSTRACT:** Solar energy is the most profuse one and is available in both direct as well as indirect forms, Drying is as a process of moisture removal due to concurrent heat and mass transfer. It is a classical method of food preservation, which provide longer shelf life, lighter weight for transportation and small space for storage. The work intends on Experimental study on the solar air collector fruits dryer using fins with electric blower. The absorber plate of solar air heater is added with corrugated fins [14]. The aim of using corrugated fins is to enhance the turbulence of air and heat transfer rate which is essential for the enhancement of efficiency of solar air collector. Air with an ambient temperature is forced to pass through the inlet of the solar collector to get the hot air at the outlet which is being used for the fruit drying process. Fruits fig is dried by equilibrium moisture content [EMC] method.

**KEYWORDS:** Drying, shelf life, corrugated fins, equilibrium moisture content, Fruitsdrying.

## I. INTRODUCTION

Energy is the means of support to the global economy. Due to the industrial globalization and economic growth the energy requirement of the world increasing rapidly [16]. The finite natural resources are depleting at rapid rate. To that alternative is the renewable energy sources, solar energy comes at the top of the list due to abundance. Solar energy is used for thermal purpose like fruits drying etc., Drying is a method of food preservation which can improve the shelf life of agricultural products mainly fruits and vegetables. Drying reduces moisture content of a product to a level below which deterioration does not occur and thus prevents fermentation or growth of moulds. Products after drying process fetch a better market price. Thus, drying helps the farmers to secure a greater economic return which in turn enhance the economy of the nation.

## II. LITERATURE SURVEY

several research has been developed on solar flat plate collector with fins of different configurations for drying and other thermal applications, present literature survey relates to analysis of solar collectors with different fin configurations past experience of various research have been reported in the literature was reviewed with the objective of assessing the relevance of geometry and configuration of flat plate collector the research studies in solar flat plate collectors are discussed .**Darshit Parikh\***, **G. D. Agrawal** : Double shelf cabinet dryer was designed, fabricated and connected to flat plate solar air heater for drying potato and green chilly. Study was performed on simple dryer (without cover and insulation) and during second on seven cases for various combinations of glass and polycarbonate sheet as glazing. drying time and dryer efficiency were estimated and found that drier with glazing showed higher efficiency.**Maneesh Kaushal, Varun** : On the basis of experimental investigation on heat transfer and friction factor of solar air heater ducts having rectangular cross-section provided protrusion-shaped roughness element on the absorber plate, the following conclusions are drawn:The friction factor and Nusselt number of roughened duct are strong functions of flow attack angle. **FouedChabane, NouredineMoummi** :studied, two types of solar air collectors and

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their performance was compared and reported that the efficiency of the solar air collectors depends significantly on the solar radiation and surface geometry of the collectors. The efficiency of the solar air collector with fins is proven to be higher. **AliZomorodian and Maryam Zamanian** : A slatted glass cover and air solar collector with two different perforated absorber plates, two thicknesses and under air mass flow rates of  $0.0056$  to  $0.0385 \text{ kgm}^{-2} \text{ s}^{-1}$  were tested. A maximum thermal efficiency of  $0.88$  was achieved for the most porous and thicker absorber plate, the absorber with less porosity illustrated a higher efficiency. **S. Suwastia, S. Abad**: Based on water content reduction, the optimum drying rate and efficiency of solar dryer with natural convection is obtained with big wave fin type. Small wave fin obtaining the lowest optimum level compared with other three fin types. Zigzag fin resulting better performance if compared with plate fin.

### III. DESCRIPTION OF EXPERIMENTAL SETUP

The setup consists of an air heating flat plate collector along with a drying cabinet for drying of agriculture product. The flat plate collector is designed and developed based on the local needs.

It consists of rectangular container box of size  $1\text{m} \times 2\text{m}$  [2] (as show in figure 2.1). The container box of a flat plate collector consists of glass wool as an insulating material of  $50\text{mm}$  thickness with low conductivity to avoid thermal loss at the back and sides of collector. Above the insulating material a aluminium foil of higher reflectivity and thickness of  $200$  microns is placed to increase the radiation on absorber plate by internal reflection.

The absorber plate made up of aluminium material of size  $1000 \times 2000 \times 0.45$  mm thick with selective coating (matte black) of  $300$  microns' thickness of coating is placed. Corrugated aluminium fins of dimension  $20 \times 10$  mm and  $0.3\text{mm}$  thickness (as show in figure 2.2). The fins material is also painted with Black matte coating to increase absorptivity.

The fins placed on absorber plate is facing towards the air inlet, this will serve of purpose of providing retention time incoming air. This cover is sealed to the collector box with sealants to avoid air leakages. solar collector is connected to dryer cabinet with a orifice meter. In this Setup was adequately equipped with instrument for measurement of various physical parameters like air temperature at inlet, Absorber plate and fins. The collector is provided with a  $50\text{mm}$  diameter pvc pipe inlet and outlet. The outlet section consists of an electric blower along with flow control valve, the air mass flow rate  $0.03\text{m}^3/\text{kg/s}$  is measured using differential water column meter connected to an orifice placed along the path of flow. This whole set up (as show in the figure 2.3) is placed in tilt angle of  $30^\circ$  due south. [11].

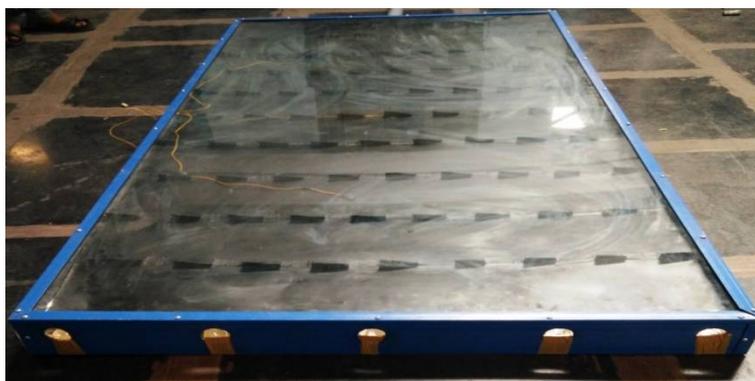


Figure2.1: Solar collector with courrgated fins.

Solar air collectors are effective devices to harness solar radiation for crop drying and other purposes, and the efficiency of solar air collector can be improved by producing new designs of fins. figure shows the collector with novel design.

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Figuer2.3: Solar air heater along with the drier cabinet.

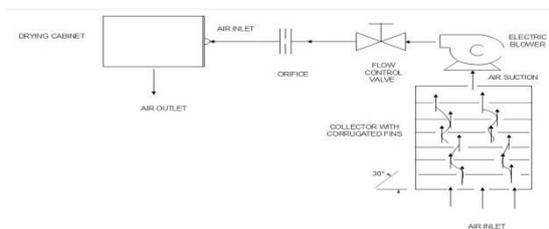


Figure 2.4: shows the line diagram and direction of air movement.

solar air heaters are extensively used in the world for heating purposes. In this study, a test of solar air heater was performed based on the heating of air by novel design fins

## IV. ANALYSIS OF COLLECTOR PERFORMANCE AND DRYING OF FIG

The air flows in a passage between absorber plate and visible glass cover of solar air heater dryer. The analysis is done on collector performance parameter with respect to absorber plate temperature, Air outlet temperature, Fin temperature, and for  $0.03\text{m}^3\text{kg/s}$  mass flow rate of air under variation of isolation and the fig moisture reduction rate by [EMC]. This analysis is made for two **days**

Formal used

- $$F_R = \frac{m' \times C_p}{A_c \times U_L} \left[ 1 - e^{-\frac{U_L A_p F'}{m' C_p}} \right]$$
- $$U_l'' = U_l' + \left( \frac{1}{F'} \right) \frac{h_{fb} U_b}{h_r + h_{fb} + U_b}$$
- $$q_u = F_R \times A_p [S - U_l'' (T_{fi} - T_a)]$$
- $$\eta_i = \frac{q_u}{A_p \times S} \times 100$$

## V. EXPERIMENTAL PROCEDURE

The procedure for the conduction of experiments. Measure the air mass flow rate using the manometer connected to orifice meter. Regulate flow control value of the collector to allow the controlled quantity of air. Simultaneously record the inlet air temperature, temperature at various points of circulating air inside the collector using K-type thermocouple and temperature indicator on hourly basis. Calculate the, average plate temperature from the measured temperature readings and then evaluate use full heat gain, heat removal factors using properties of air in thermal data hand book. Drying of fig is carried during morning 9:00AM to the evening 4:00PM. It takes 14 hours to dry the fig for

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1000gms to 271gms in which 728 gms of moisture content is removed. The fruit was decided as edible by EMC method.

## V. EXPERIMENTAL RESULTS

Results based on two days reading data. In this, Absorber plate temperature with time, Fin temperature with time, Air temperature with time, Fin effectiveness with time, Fig moisture with time day1, Fig moisture with time day2.

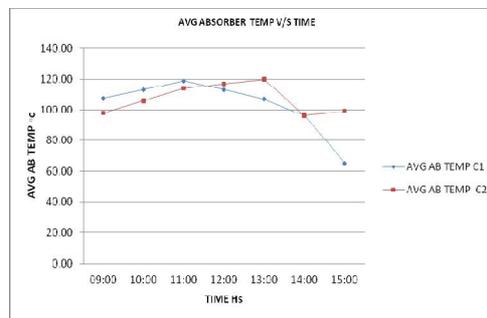


Figure 5.1: Variation of absorber plate temperature with time of collector.

Figure 5.1 Variation of absorber plate temperature with time during month of May and indicated that plate temp was higher during the time of 11:00 Am to 13:00 PM. The dependency of mass flow rate of air clearly indicated that for higher mass flow rate the temperature was lower owing to greater heat removal from the plate. The maximum temperature was 126°C for 0.03kg/s flow rate during 11:00 AM to 13:00 PM.

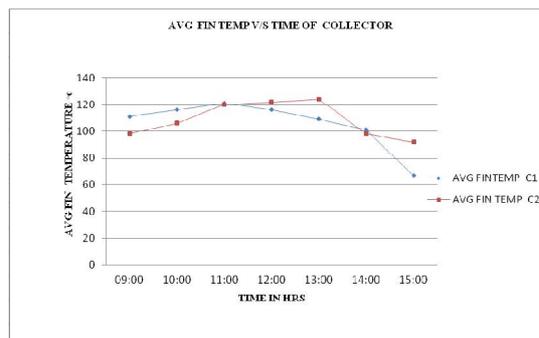


Figure 5.2: Variation of Fin temperature with time.

shows the variation of the Fin temperature with the time during month of May and indicated that the Fin temperature were higher during the period of time of 11:00 Am to 13:00 PM as red line indicates the maximum temperature.

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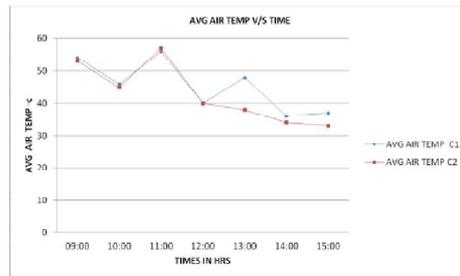


Figure 5.3: Variation of air temperature with time. The air temperature were higher 57°C during the period of time of 10:00 AM to 11:00 AM.

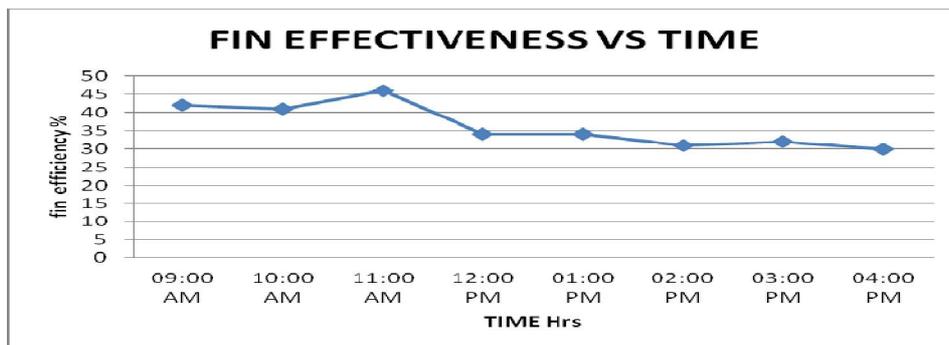


Figure 5.4 Shows Fin Effectiveness V/S Time

Thermal efficiency of the collector configuration which indicates a maximum efficiency value of 46% and also fin efficiency and overall efficiency show similar trend of variations.

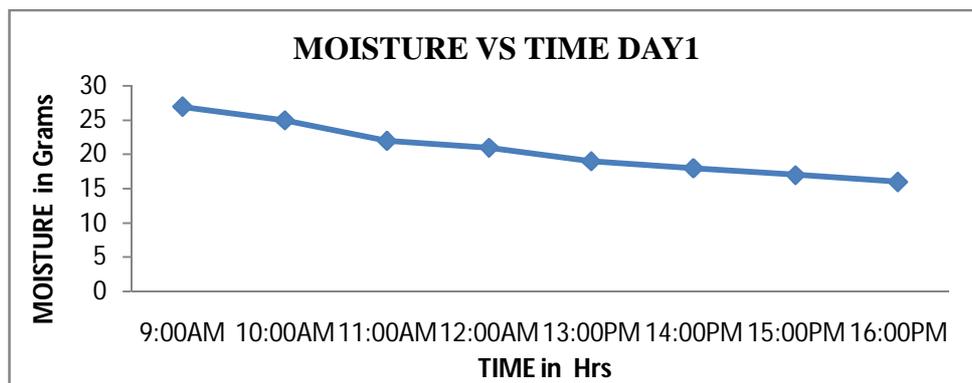


Figure 5.5 :Moisture vs Time Day1, figure shows the reduction in the moisture content present in fig fruit over a period of time , an accelerated rate of fall in moisture was found in the beginning later the rate is found to constant over a period .

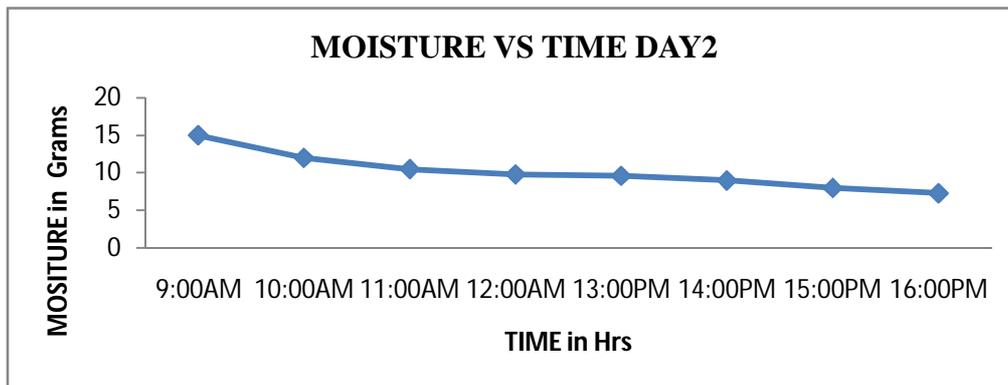


Fig 5.6:Moisture vs Time Day2,figure shows the reduction in the moisture content present in fig fruit over a period of time, the rate of moisture reduction is found to be same as day1 .

As figure 5.6 shows moisture content is decreased for 27 gm to 16 gm and on day2 15 gm to 7.3 gm.

## VI. CONCLUSION

The solar fruit dryer indicated the following conclusion. The maximum absorber plate temperature recorded was 126°C for 0.03 m<sup>3</sup>kg/s flow rate.The lower flow rate of air facilitated higher temperature with 57°C being the highest air temperature at 0.03 m<sup>3</sup>kg/sec and 48°C during period closer to solar noon.The fin effectiveness was high for higher mass flow rate with maximum of 46% at 4:00 PM, and low at 32% 11:00 AM. Hence fin effectiveness and overall efficiency show similar trend of variations.Moisture content of fig suddenly decreases between 2 to 3 gms during starting and later it decreases at slow rate between 1 to 2 gms. And was determined by EMC method.

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