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Experimental Study of Effects of Air on Drying of Banana in a Fabricated Solar Drier

KEYWORDS: Solar Energy, Solar Cabinet Drier, Solar Collector, Air Flow Rate, Drying

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ABSTRACT The technological development of rural community has been severely hampered by the lack of adequate energy supply to the villages. Reaching these villages through conventional energy sources may be prohibitively expensive. Solar energy is abundantly and cheaply available in all these remote villages. Solar Drying experiments in thin layer drying of banana were conducted in Natural Convective Fabricated Solar Cabinet Drier consisting of Flat plate collector and a drying cabinet with perforated trays and aspirator. A glass panel of 1.00x2.00 m dimensions was fixed at an angle of 45° to the cabinet. This provision was to enable entrapment of solar radiation between the glass and black painted surface of the cabinet. This entrapped solar radiation in turn heats up the air within the dryer. The energy required to dry banana from 90% to 12% in three days (6 hrs /day) was calculated. The solar air heater was calculated for their performance at no load condition with varying flow rate of natural circulated air. Three drying trays were used for drying purpose. The maximum outlet temperature of 62 ^{0}C was obtained at the flow rate of 2.08 m^3/s when the inlet atmospheric air temperature was 36 ^{0}C.

INTRODUCTION

Drying of agricultural products is one of the most important aspects covered in the post-harvest technology in processing engineering. "The term drying refers to the removal of moisture from agricultural product to a level that is in equilibrium with normal atmospheric air in order to preserve the quality and nutritive value as food, feed and its viability as seeds." Drying involves a large amount of heat energy, which is either from renewable or non-renewable sources. The shortage of non-renewable sources has compelled the related authorities and scientist concerned to exploit the use of renewable sources of energy such as solar, biogas, wind etc.

The age old method of drying materials with solar energy by spreading on the ground for direct exposure to solar radiation requires open space, manual labor for material handling and involves low temperature heat for removal of moisture. To reduce any possible contamination and improve the product quality, it is essential that the drying be enclosed and dehydrated under controlled conditions, non-uniform drying may result in formation of cracks in the kernels.

In order to avoid the application of conventional forms of fuels and cut down the operative costs of drying of products alternative source of energy is to be allocated which is cheaply or freely available, solar energy can effectively be utilized for the purposes as it is abundantly available and may serve the task. Direct lined glass/plastic covered solar dryers often referred as natural dryer. Usually one or two layers of transparent covers are provided depending upon the temperature required for drying. In directly heated solar dryers in whom air was heated in a solar heater was supplied to separate drying chamber. Different investigators worked on different designs and configuration of air heaters.

The present paper discusses the design and fabrication of solar cabinet drier to dry high moisture hygroscopic grain (Banana) in three consecutive trays in 6 hours a day for three continuous days. In present case solar cabinet drier was evaluated at no load condition for an hour for a typical day in summer at Allahabad in Uttar Pradesh (India). The overall performance has been encouraging and discussed in the paper.

2. MATERIALS AND METHODS

2.1 FABRCATIONAL ASSUMPTIONS

The following parameters were considered while fabricating the solar dryer.

I Scale of use.
II Temperature it retains in all- weather consideration.
III Type of material to be dried.

IV Efficiency of drying.
V Cost economics.

Based on the above parameters he following assumptions was made:

I the loss of heat from the cabinet was negligible.
II there is uniform circulation of air inside the dryer.
III there is no air leaks from the cabinet.
IV there is no loss of heat from the duct connecting collector and drier

2.2 FABRICATION OF DRYER

Solar Cabinet drier consist of three major parts i.e. solar collector, duct section and drying chamber.

2.2.1 Solar collector

For this unit, a frame of the size 1x2 using mild steel was made. Additional mild steel angles were also provided at top and bottom to screw with the base and to fix the glasses. This frame was covered with single sheet aluminum so that there is no chance of corrosion or rusting. It consists of the collector box, insulating material, absorber and glass. The frame was covered with black painted copper plates with black and glass wool inserted between plates and frame. The collector was fixed at an angle of 30° to the base. This provision was to enable entrapment of maximum solar radiation between the glass and black painted surface of the cabinet. This entrapped solar radiation in turn heats up the air within the duct passing through the collector.

2.2.2 Duct Section

Duct section was provided above the absorber plate for air to flow to fix the transparent cover, metallic bolted with nut and bolt provided on sides of the frame. A two inch pipe was used to connect the collector to the drying chamber. The pipe was tightly wrapped with glass wool.

2.2.3 Drying Chamber

The frame of the dryer was made of angle iron of dimensions 1" and 1". The frame built to take up the load of the cabinet and other parts of the dryer. Mild steel sheets of 24SWG covered the frame. These sheets were painted inside and outside with boiler paint so that the whole surface simulated a black body effect. The paint also helped to protect the structure from damage caused by rust. After that it a insulating material was pasted on the whole body of the drying chamber. The Overall dimensions of the drying chamber is 600mmx600mm, the height of the chamber was 1200mm. Four perforated aluminum trays were provided within the drying chamber to hold the materials that were to be dried. The trays were of same size. A set of four trays of 23" x 23" was used. The collective holding capacity of the trays was 4-5 kg .Schematic of the fabricated solar cabinet drier is shown in figure 1. Also a full photo of the whole drier is shown in figure 1.

aSchematic of Drier **b Photo of Drier**

Fig 1 Experimental Laboratory Solar Cabinet Drier

2.3 Test Procedure

The experiment was conducted at the Mechanical Engineering Department, Shepherd School of Engineering and Technology of Sam Higginbottom Institute of Agriculture, Technology & Sciences (Deemed-to-be-University), Allahabad.

2.3.1 At no load condition

Variation in air temperature, relative humidity and air velocity inside and outside the dryer when not loaded was observed and readings were taken respectively.

2.3.2 At load condition

After testing the dryer at no load condition the dryer was tested for loaded conditions taking the ambient temperature, Ist inlet and 2nd inlet temperatures and outlet temperatures.

Sample of 5 kg Banana was bought from the market and then cleaned, sliced and carefully spread on the tray. Dryer was checked for proper amount of sunlight supply. The readings were taken at each hour consistently for 8 hrs for three consecutive days. Initial moisture of Banana was 93.5%.

3. EXPERIMENTAL PROCEDURE

After the fabrication of the experimental set up a detailed investigation using different instrumentations has been carried out to assess the performance of the dryer. A Solarymeter was used to measure the solar radiation. Thermometers and the thermocouples were used to measure the inlet and outlet temperature. For the performance study the following data were collected:

- Solar incident radiation on the air heater collector surface
- Air heater collector, dryer and ambient temperature
- Humidity in the drying chamber and in the ambient air
- Mass flow rate of air in the dryer
- Weight of the sample at time to time

Final dried banana is shown in the figure 2

Fig 2 Solar dried Banana

4. RESULTS and DISCUSSION

Blanched sample of banana was dried in the solar dryer and different parameters like drying air temperature at inlets and outlet, air velocity inside the dryer and moisture losses were recorded for three consecutive days. The results of the investigation have been discussed below.

4.1 Variation in air temperature

Hourly variation in the temperature of ambient air and drying air at two inlets and one outlet of the dryer for two consecutive days of drying for batch loading of banana samples in the month of August. Figure 3 reveals that the drying air temperatures were lower in morning at 10 am and in evening at 5 pm. The minimum drying air temp at 1st inlet on first drying day and second drying day were 41 °C and 47 °C respectively. At 2nd drying-air inlet the minimum temperature were 43 °C and 50 °C on 1st and 2nd drying day respectively. The maximum drying temperature achieved during two consecutive drying days for banana was 69.5 °C at 1 pm on 1st drying day in 2nd inlet. And for 2nd drying day in first inlet it was 52 °C at 1pm, when the ambient temperatures at both the times were 37 °C. There were about 10 °C temperature differences between two inlets of drying air. The outlet air temperature was slightly more than that of ambient air, and the maximum outlet air temperature was observed to be 48 °C on second drying day at 3 pm. Fig shows that solar intensity was fast during 10 am to 2 pm on both observation days and it also shows that the temperature falls rapidly in the evening.

4.2Variation in air velocity

It was observed that air velocity depends upon rise in temperature of air inside the dryer (figure 4). The maximum air velocity attained by dryer was 0.55 m/s at 1 pm when temperature was 36 °C on the 1st day of the observation. The rate of moisture evaporation was high on the first drying day. The average air velocity inside the dryer was 0.173 m/s and the average atmospheric air velocity in two days of batch loading for banana drying was 0.372 m/s.

4.3 Variation in Relative Humidity

The Fig clearly reveals that there is no significant reduction in relative humidity of drying air for batch loading of tomato from 1st day to 2nd day. The ambient air relative humidity

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had also not attained significant changes; it changes from minimum of 55% to maximum of 70% for both consecutive days.

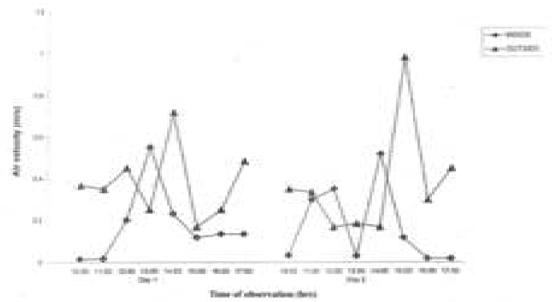

Fig 3 Variation of air velocity with time

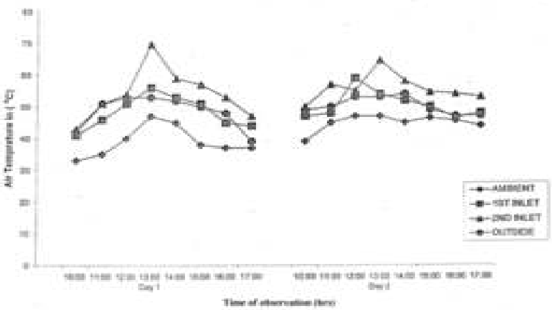

Fig 4 Variation of air temperature with time

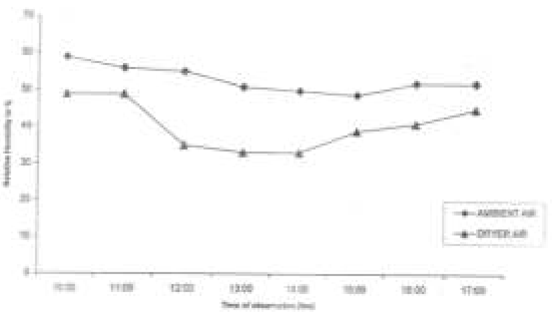

Fig 5 Variation of Air Relative Humidity with Time

5. CONCLUSION

The fabricated low cost dryer worked satisfactorily for drying of Banana. This adds no complexity to design, operation and maintenance of system. It dried almost 4 to 4.5 kg of Banana from 93.5% moisture respectively to 11.23%. It was about 60% more efficient than the traditional sun drying method as the loss of hot air was restricted and heating was continuous and uniformly applicable. The solar radiation falling on the collector can be controlled by changing the direction of the dryer; so that the temperature rise in the drying chamber can be controlled and hence drying can be made more effective for any other agricultural products too. Due to the low cost incurred in its manufacturing and based on its performance we can easily recommend it for the farmers.

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