Forced Convection Solar Dryer System

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Abstract – *This paper presents the design and construction of a solar dryer for drying agriculture product such as banana. In many countries of the world, the use of solar thermal systems in the agricultural area to conserve vegetables, fruits, coffee and other crops has shown to be practical, economical and the responsible approach environmentally. Solar heating systems to dry food and other crops can improve the quality of the product, while reducing wasted produce.Under the module of Advance topics in mechanical engineering projects.*

Keywords- Solar Heating System, Solar Dryer System

I -INTRODUCTION

Drying is a process of dehydration of food products which means reducing the moisture content from the food to improve its shelf life by preventing bacterial growth.we have introduced a high efficiency low cost vegetable dryer for our advance topic in mechanical engineering module. This dryer has been designed to construct from material available in the market at low cost. This especially to over come the problems encountered in the sun drying such as many disadvantages such as spoilt products due to rain, wind, dust, insect infestation, animal attack and fungi. This dryer consists of main parts namely Solar collector, Solar chamber, Chimney, Trays.

II - LITERATURE REVIEW

[1] Bukola O. Bolaji.et.al :- Designed, constructed and tested the solar wind-ventilated cabinet dryer in Nigeria on latitude 7.5° N.Comparatively, drying with the solar cabinet dryer showed better results than open air-drying. During the period of test, the average air velocity through the solar dryer was 1.62 m/s. The maximum drying air temperatures was found to be 64°C inside the dryer.

[2] M. Mohanraj, P. Chandrasekar :- The performance of an indirect forced convection solar drier integrated with heat storage material was designed, fabricated and investigated for chili drying. The drier with heat storage material enables to maintain consistent air temperature inside the drier. The inclusion of heat storage material also increases the drying time by about 4 h per day. The chili was dried from initial moisture content 72.8% to the final moisture content about 9.2% and 9.7% (wet basis) in the bottom and top trays respectively. They concluded that, forced convection solar drier is more suitable for producing high quality dried chilli for small holders.

[3] Diemuodeke E. Ogheneruona, Momoh O.L. Yusuf :- Designed and fabricated direct natural convection solar dryer to dry tapioca in rural areas. A minimum of 7.56 m2 solar collector area is required to dry a batch of 100 kg tapioca in 20 hours (two days drying period).

III - METHODOLOGY

The solar food dryer is generally constructed by wood because it is easily available and light in weight and cost. Since the entire casing of wood only the top of air heater chamber is made, the major construction works of solar dryer is carpentry works.

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The following material is applied to make fullfill the solar dryer :
1) 12mm Plywood 2) Cover sheet 3) Fevicol, adhesives 4) Waterbond solvent 5) Nails and screws 6) Net 7)12v Blowing fan 8) PVC (pipe, coupling and elbow).

Image : 1 , Solar Collector   Image : 2 , Solar Chamber

Image : 3 , Complete Assembled Solar Dryer

IV - DESIGN

Consideration - All The design is made for the optimum temperature for the dryer.T0 of 65°C and the air inlet temperature or the ambient temperature of dryer as T1=35°C.The design of the drying chamber is made as spacious as possible dimension of 20×13×20inch.

Drying Chamber, with dimension of 20×60×5inch Solar Collector at inclination of 30°. And the supporttable frame is the dimension of 36×13inch. Five trays are made up of metal net. The tray dimension is 19×11.5inch.

Calculation - Solar Collector / Air Heater Angle of Tilt (β). It states that the angle of tilt (β) of the air heaters

$$\beta = 10° + lat\phi \ ....(1)$$

Where latitude of Jalgaon is approximately 21N so angle of tilt is 31° to horizontal.

Moisture contents according to the following simple formula.

$$Mc, (w.b,\%) = ((m_i - m_f) \div m_i) \times 100 \ ....(2)$$

Where, m_i and m_f are the initial and final mass, (kg). if moisture content within the experimental campaign were determined with two hours intensive as the represen - tative samples.

V - RESULT & DISCUSSION

The comparison of moisture content for different flow rates (0.5,1 and 2m/s) over drying time. The maximum temperatures achieved with 0.5, 1 and 2m/s are 49.5,45 and 41°C, respectively,with almost similar ambientair temperature for all the velocities. At the end of 2 days of drying, i.e.16h, the moisture content in the bananas is 34.98, 29.63 and 36.04% for 0.5,1 and 2m/s, respectively.If the absolute moisture removal rate is considered then the moistue removal rate is fastest with the velocity of 1m/s, followed by 0.5 and 2m/s.
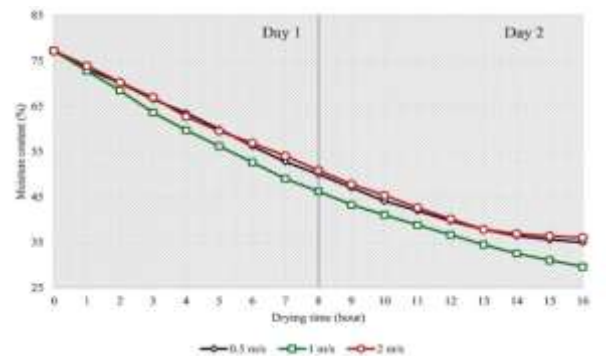
The quality of the products obtained is more important. It is noted that with velocity of 0.5 m/s, the dried banana obtained has cardboard-like structure, hard outer surface, too light and looks like not ripened which is unacceptable. Because of the faster rate of moisture removal with 0.5 m/s, the rate of evaporation increased which resulted in hardening of the surface.

0.5m/s   1m/s   2m/s

Image : 4 , Dried Banana Sample

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On the other hand, the rapid cooling of the surface of banana slices due to faster air velocity with the air inlet velocity of 2 m/s resulted in dark colour with blackening of the surface, and the surface became hard. Due which the banana obtained is of unacceptable quality.

But the banana samples obtained by drying at a velocity of 1 m/s at the collector inlet are having more consistent quality of dried banana with good colour, texture, no dusty appearance, chewy and natural aroma. So with 1 m/s, good quality of banana can be obtained with quite high drying rates. The dried banana samples obtained with different air velocities were also compared with the dried banana samples. These also confirm that the dried banana samples obtained by a velocity of 1 m/s are acceptable.

VI - CONCLUSION

Drying constant was found denoted fast drying processes for the forced convection against the passive. Drying system efficiency for the forced convection was higher for the first day comparing with the following days due to the fast drying in the moisture falling stage.   At the end of 16 h of drying, about 3.1 % difference in moisture content is obtained between the two configurations which is significant. The result also shows that the banana dried at flow rate velocity of 1 m/s over the collector is of the best quality in terms of color, taste and shape. The result also shows that the banana dried at velocity of 1 m/s over the collector is of the best quality in terms of colour, taste and shape when compared to drying at 0.5 and 2 m/s flow rate for the same solar energy input and atmospheric conditions.

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