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PERFOMANCE ANALYSIS OF FORCED CONVECTIVE V-GROOVE SOLAR AIR HEATER FOR DRYING TOMOTA SLICES

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Abstract

In this research the surface modified solar air heater has been developed and experimentally investigated for drying of tomato. The moisture content of the tomato has reduced from initial moisture content of 94.4% to the safest moisture content of about 15%. The time taken for the moisture reduction of tomato to safest MC is 72 hrs of discontinuous sunshine. To attain this moisture content the flow rate has been maintained at 0.03kg/s during the drying process. This solar dryer enhanced the temperature due to the surface modified absorber plate. This dryer has V-grooved absorber plate which has an angle of 60º and has total area of 1m^2. This experiment achieved an efficiency of 25%.

Keywords: solar dryer, V- Grooved absorber plate, tomato, moisture content, efficiency.

INTRODUCTION

Increasing population is a grand challenge to balance between the food production and food consumption. To overcome the food shortage, the food security needed to transform some practices of storage, food production, distribution and consumption. The improper drying leads to serous losses. For safe storage, drying plays an important role in food security. Different drying techniques are used for food storage such as drying, dehydration, preservation, microwave and freezing, solar drying. Drying plays an important role in global development. The common problems faced by developing countries are preservation of agricultural products. The important form of food production is drying. Drying is an essential process in unit operation for food preservation it removes the moisture content and increases the shelf life of the product. Drying of agricultural products is a essential process to remove the initial moisture and make the products available for storage without any degradation. In most of the countries the food problems arise due to the insufficiency to preserve food surpluses rather than due to low production. In drying the energy need is accomplished by either via renewable or non renewable energy sources. Solar drying is mostly used at the farm level because it is low environmental impact, and low cost for drying food products and agricultural products. In agricultural sector about 30% of world's energy is consumed among that 3.62% of energy is utilized for drying. Based on mode of operation dryers can be divided into active and passive.The temperature is measured by using thermocouple at different locations. Among the different types of natural convection solar dryers the mixed mode solar dryer is higher in speed of drying. The solar drying is an best alternative method for traditional drying.For a proper drying the even distribution and flow uniformity of the turbulence intensity over the drying product are important for proper drying. In the mixed mode solar dryer the drying temperature is maintained in the range of 40-60°C and the ambient temperature is about 15-30°C.The hot air temperature required for the safe drying is 40-60°C.In shorter duration the removal of maximum moisture level which saves the electrical energy. For safe drying of

vegetables requires hot air in the temperature of 40-60° C. So that they will choose the solar dryer for energy saving.

METHODS

Methods of Solar dryer

When there is food spoilage, there develops a food shortage. To equalize the supply and chain there comes the drying unit. Traditional dryers are tie consuming and has a possibility of contamination. The comparison of solar drying to different drying options and shows benefits to existing drying methods. Better ventilation has a good output of preserved food products. The drying process in the traditional way is taken i thee open field. To prevent these contamination particles solar dryer is best alternative source of drying. The constant temperature and air flow leads to the consistent drying process with better quality. There are many developed solar dryers such as

i.Direct drying
ii.Indirect drying
iii.Mixed mode drying

INDIRECT MODE OF CONVECTIVE SOLAR DRYER

In indirect type of solar dryer, the solar collector separately absorbed heat energy and transferred to the drying chamber by natural or forced convection. The indirect type solar dryer is commonly used to increase the drying performance and to preserve the quality of food products during the drying process. It solar collector, drying chamber, and blower assembly for airflow. This type of dryer increases the product quality by means of closed area.

FORCED MODE OF CONVECTIVE SOALR DRYER

The forced mode of convection over the food through the use of fan. It requires a power source for the fans to provide the air flow it doesn't require an inclined for the air flow and the collector placed horizontally with the fan at the one end and drying bin at the other end. The forced convection dryer on solar energy is less dependent as it provides an air flow itself. The continuous ventilation in forced convection solar dryer requires a blower to force air through over the product. The natural convection dryers are time consumption unit, whereas the forced convection dryers need electrical source for air inlet and to maintain the air flow rate. It reduced the drying time higher drying capacity and better quality of the product. The forced air circulation is better than the natural air circulation of required drying conditions and does not require any other energy.

System Description

V-Groove

V-groove plate was used as an absorber. V-groove absorber has a fined shape with large area of the absorbent.The main advantage of the system is that it has doubling the heat transfer area which also increases the heat transfer to the air. Double flow V-grooved absorber has 4-5% additional efficiency when compared with single mode. The highest efficiency value of V-groove double pass flow collector is due to large contacting area of the V-groove absorber. In this type of absorber the air gets contact with both sides of the absorber.

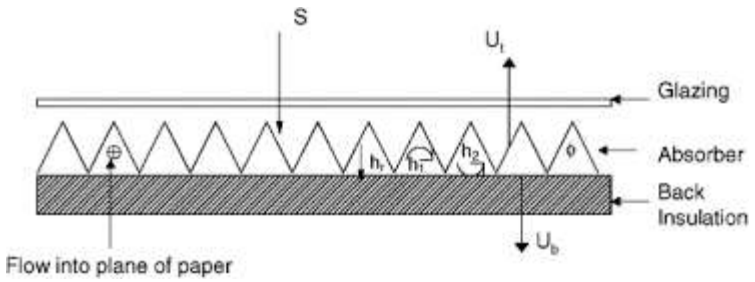

Fig. 1 V- Grooved absorber plate

THERMOCOL INSULATION

The standard thermocol sheet size thickness 39''x19'' is used in the SAH to reduce the system loss. The sheets are packed and stacked together in a bundle or pocket. A closed cell structure and support low thermal conductivity. It is used for thermal insulation and it resist -5 to 500°C temperature.

GLASS COVER

Glass cover is used as the insulation material which helps to minimize the heat loss. The principal work of the glass cover is glazing which helps to convert the short wavelength to long wavelength radiation, the more heat energy is absorbed in the plate and it reduced the heat loss. The thickness of the glass cover for the solar heater is 0.5 mm.

EXPERIMENTATION STUDY

The experiment conducted for drying tomato slices. Tomatoes are quickly affected by microorganisms since it has highest moisture content. To reduce that the indirect mode solar type forced convection dryer has been used in this study. The Tomato slices with a thickness of 2 mm and it placed in the drying chamber.The solar air heater is designed with an dimension of 1m length, 0.7 m breadth and 0.5 m width (1 m x 0.7mx0.5 m). The glass cover is used as a top cover for sir heater. The main part of the solar air heater is V-groove absorber plate. Thus the heat transfer coefficient is increased .It increases the surface area of the solar air heater thus enhances the Reynolds and Nussle number. The solar air heater with maximum temperature is recorded during the high sunshine hours of 1:30 PM with the solar radiation range of 890 W/m^2. The sun is absorbed by the absorber plate from

the solar radiation. The radiation from the sun has short wavelength. This long wavelength will converted into long wavelength once it reached the space between absorber plate and glass cover. The solar air heater receives air from the blower and which passes through the V-groove absorber plate and then the air gets heated and come out through the outlet. The solar air heater receives air from the blower and which passes through the V-groove absorber plate and then the air gets heated and come out through the outlet. The heated air passes inside the drying chamber and dries the tomato sample which placed inside the drying chamber.

CALCULATION DESIGN*:*

Equilibrium can be presented by the following equation,

.

$$M_w h_{fg} = m_a C_p (T_{OC} - T_{ic})$$

The heat energy from the collector

$$Q=HR(\alpha\tau)tA_c\eta_c$$

The moisture removal equation,

$$M_w = m_i (M_i - M_f)/ (1-M_f)$$

The efficiency relation,

$$\eta_c = Q_u / HR\ A_c$$

Th drying cabinet efficiency which includes power consumption,

$$E_d = P\ h_{fg} / (HR\ A_c + W)\ t$$

Air heater efficiency,

$$E = m\ c_p\ T / IV$$

The moisture content determination for the product

$$M = (W_s - W_d / W_s)\ x100$$

TIME	T_{in}	T_{out}	T_p	T_{DC}
10.00	32	48	46	44
10.30	35	53	50	52
11.00	33	58	62	57
11.30	34	60	67	59
12.00	33	61	69	60
12.30	34	62	70	61
1.00	35	63	72	62
1.30	34	62	73	61
2.00	33	60	70	59
2.30	32	59	68	57
3.00	33	55	64	54
3.30	33	53	60	52
4.00	30	48	55	46

Fig.2 Table values of inlet, oulet and plate temperatures of SAH

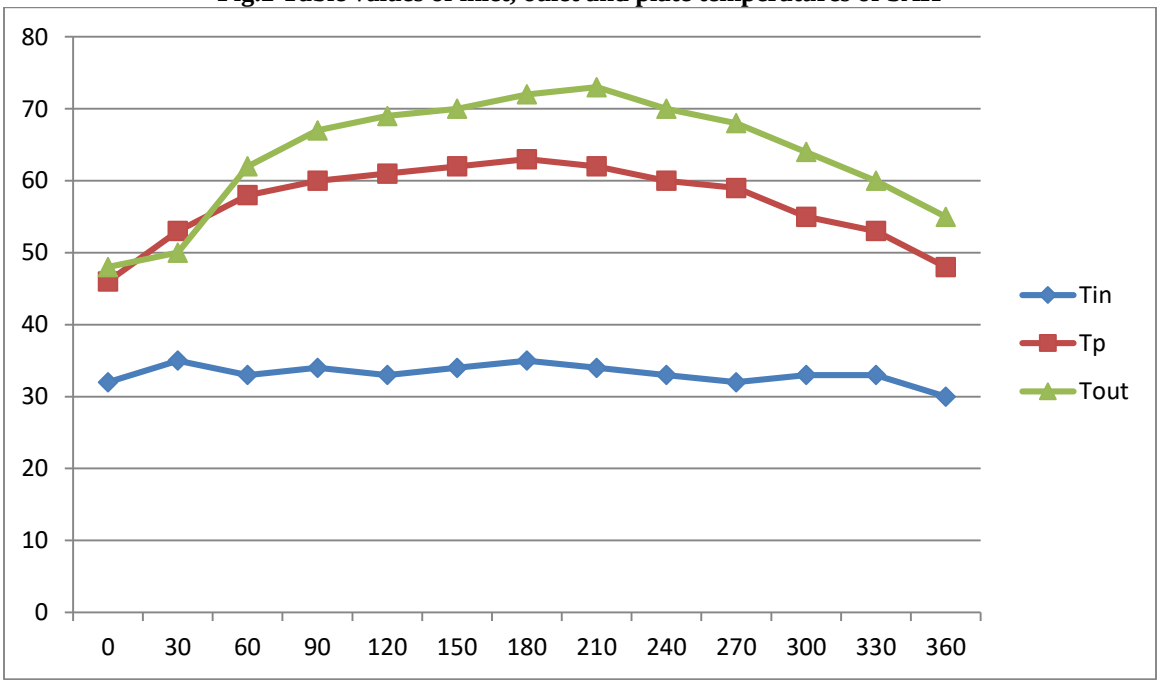

Fig.2 Time VS Temperature

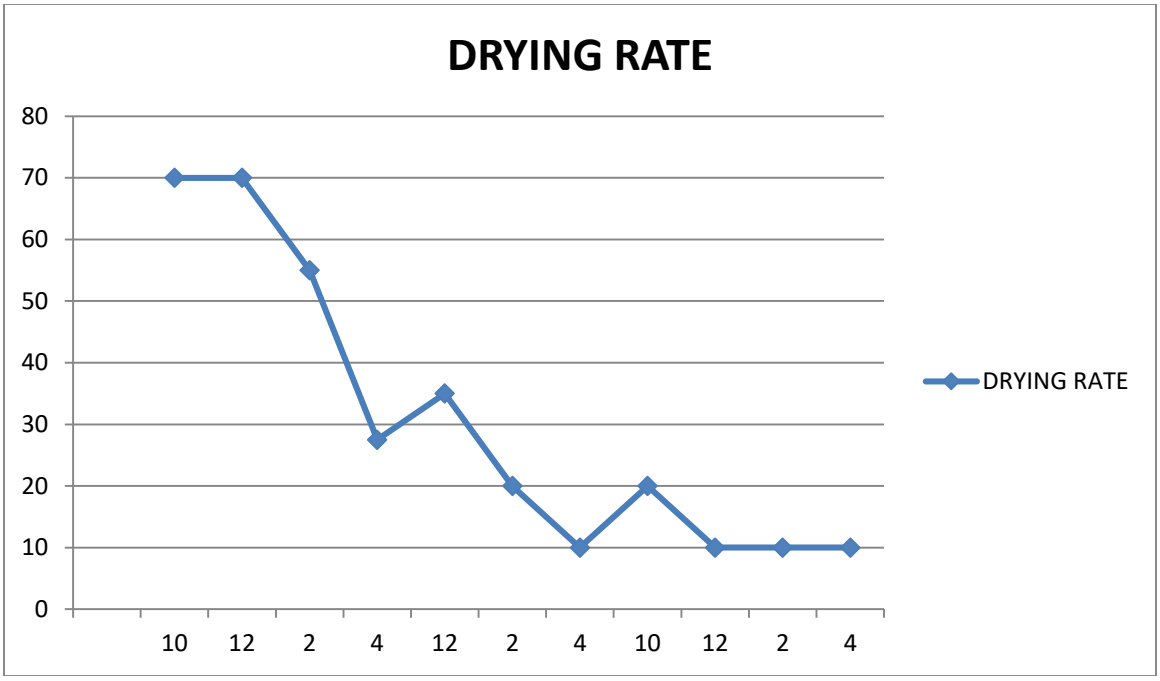

Fig.3 Drying rate VS Time

Conclusion

There are different types of solar dryers used to preserve food from wastage as well as value addition. The maximum temperature obtained is 63º C. The different solar drying methods were mixed mode type, forced convection type, indirect mode natural convection type, cabinet type solar dryer, desiccant solar dryer, evacuated tube solar dryer, hybrid solar dryer, tray drier are more efficient than the open sun drying method. When compared with traditional drying this solar dryer provides more quality products without contamination.

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