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Performance Enhancement of Solar Dryer

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ABSTRACT: The present paper surveys literature on performance enhancement studies on solar dryer with a thrust on energy efficiency improvements in solar air collector and a solar drying system. The effect of adoption of absorber plate with glass solar air collector of fins. Food materials and crops are very sensitive to the drying conditions. Very short duration with high speed drying would caused a quality of dried product will be reduced due to over or under dry.

KEYWORDS: Solar collector, Air heater, Blower, Fin strays.

I. INTRODUCTION

Solar dryers are exerting in agriculture field for crop drying also used for industrial drying processes. For drying of products, high temperature and no cloudy weather in surrounding air are required [1]. Wear facing the challenge of food safety drying in open space takes much more time. Solar dryer removes a certain percent of moisture content from the product using solar energy [2].

The solar dryer can be seen as one of the solutions to the world's food and energy crises [3]. With drying most agricultural produce can be preserved and this can be achieved more efficiently through the use of solar dryers [4]. It is used for three types solar dryer combined, electrically coil solar dryer, air heater solar dryer, fins types solar dryer [5]. In solar drying, solar dryers are specialized devices that control the drying process and protect agricultural product from damage by insect, dust and rain [6]. Drying process is of great importance in food industries. Drying of agricultural products has a number of advantages, e.g. shelf life extension, quality improvement, and loss reduction.

II. RELATED WORK

FABRICATION AND ASSEMBLING

Design Analysis

Temperature The minimum temperature for drying red chill is 35°C and the maximum temperature is 65°C, therefore. 50°C and above is considered average and normal for drying fruits, vegetables, red chill. Efficiency this is defined as the ratio of the useful output of a product to the input of the product.

Glass and flat plate solar collector It suggested that the glass covering should be 4mm thickness. In this work, 4mm thick transparent glass was used. It also suggested that the aluminium of 2.0mm thickness was used.

Dryer Trays Net (fins) was selected as the dryer screen or trays to aid air circulation within the drying chamber. Three trays were made of fins net. The dryer dimension is 30×30cm. Exit hole is used to remove the air from the drying chamber.

The design of the dry chamber making use of wooden wall sides and a top protects the food to be placed on the trays from direct sunlight since this is undesirable and tends to bleach colour, removes flavour and causes the food to dry unevenly.

4.2 The following tools were also used during the other construction;

1. Hand saws (crosscut saw and rip saw).
2. Jack plane.
5. Mallet
6. Pinch bar and pincers



- 3. Wood chisel.
- 4. Hammer
- 7. Electric cutter machine
- 8. Screw driver

4.3 MATERIAL USED

III. METHODOLOGY

The following materials were used for the construction of the solar dryer

- 1. Being a good insulator and relatively cheaper than metals.
- 2. Glass as the solar collector cover and the cover for the drying chamber. It permits the solar radiation into the system but resists the flow of heat energy out of the systems.
- 3. Mild steel sheet of 1mm thickness and aluminium painted black for absorption of solar radiation.
- 4. Fins frame for constructing the trays.
- 5. Nails and glue as fasteners and adhesives.
- 6. Insect net at air inlet and outlet to prevent insects from entering into the dryer.
- 7. Absorber plate Paint

Solar Dryer Components

SI. NO.	COMPONENT	MATERIAL	DIMENSION
1.	Solar Collector	Glass	73x28cm
2.	Absorber Plate	Aluminium	58x28cm
3.	Heating Chamber	Wood	46x51cm
4.	Drying Chamber	Wood	46x51cm
5.	Trays	Fins	30x30cm

Drying chamber

The drying chamber was made up highly polished aluminium consist of three drying trays also made of fins, the material has been chosen since aluminium is a good conductor of heat and its smooth surface finish and also heat loss by radiation is minimized.

Cover plate

This is a transparent sheet used to cover the absorber, thereby preventing dust and rain from coming in contact with the absorber, it also retard the heat from escaping, common materials used for cover plates are glass, fibre glass, flexi glass, but the material used for this project is glass.

Absorber plate

This is a metal painted black and placed below the cover to absorb, the incident solar radiation transmitted by cover thereby heating the air between it and the cover, here aluminium is chosen because it's quick response in absorption of solar radiation and also copper because of its good ability to keep the absorbed solar radiation.

Air heaters

Air heaters are devices used to heat air. They include forced air products as well as all types of radiant and space heaters. Forced air products moderate and control air temperature by circulating air past a heat source with a fan or blower.

Insulation

This is used to minimize heat loss from the system, it is under the absorber plate, the insulator can withstand stagnation temperature, it is fire resistant and not subject to out-going gassing and it is damageable by moisture or insect, insulating materials are usually fibre glass, mineral wool, Styrofoam and urethanes, but here Styrofoam was chosen.

Solar collector

The flat-plate solar collector was always tilted and oriented in such a way that it receives maximum solar radiation during the desired season of used. The best stationary orientation is due south in the northern hemisphere and due north in southern hemisphere. Therefore, solar collector in this work is oriented facing south and tilted at to the horizontal.

Heating Coils

A coil is a heating element attached to the heating unit itself. The heater generates the electric current which flows into the coil. The heating coil transfers the electric energy into heat energy.

Operation of the dryer

The dryer is a system in the sense that it has no moving parts. It is energized by the sun's rays entering through the collector glazing. The trapping of the rays is enhanced by the inside surfaces of the collector that were painted black and the trapped energy heats the air inside the collector. The green house effect achieved within the collector drives the air current through the drying chamber.

If the vents are open, the hot air rises and escapes through the upper vent in the drying chamber while cooler air at ambient temperature enters through the lower vent in the collector. Therefore, an air current is maintained, as cooler air at a temperature T_a enters through the lower vents and hot air at a temperature T_e leaves through the upper vent. Solar radiation can be converted either into thermal energy (heat) or into electrical energy. This can be done by making use of thermal collectors for conversion into heat energy or collectors for conversion into electrical energy.

Two main collectors are used to capture solar energy and convert it to thermal energy; these are flat plate collectors and concentrating collectors. In the course of this project, emphasis is laid much on the flat plate collectors which are also known as non-focusing collectors.

IV. EXPERIMENTAL RESULTS

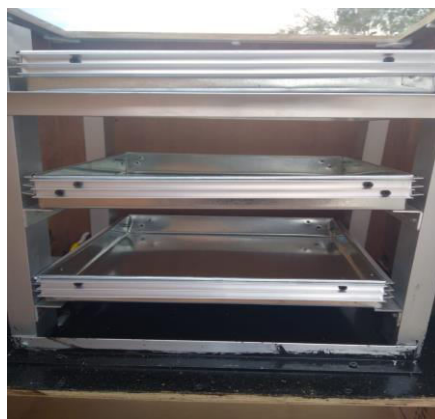


FIG-1(FINS TRAYS)

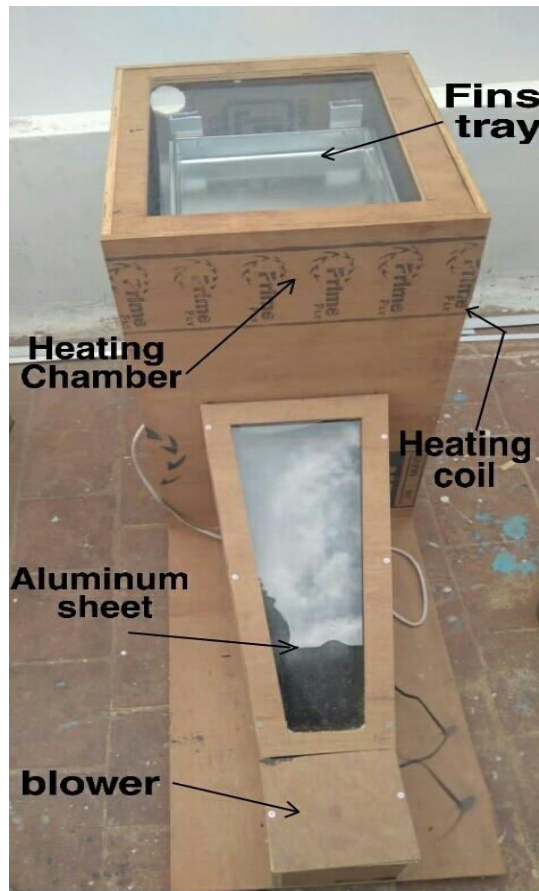


FIG-3(FINAL PROJECT)



FIG-2(WOODAN FRAME)



V. RESULTS AND DISCUSSIONS

The experiments were performed on red chillies. The drying time is 4 to 5 hours. The energy and energy analyses of the solar drying system for red chilli were performed in this study. Given the results from these analyses, the following remarks may be concluded:

It was reduced moisture from 90% to 15%. Result of the present study shows that the drying time is reduced and quality of the final products are superior.

The results have been shown graphically. A digital thermometer was used for the temperature measurement in the solar dryer, the initial moisture content was measured using variation in weight loss was measured using an electronic scale.

The red chillies were dried by natural convection in reducing the weight solar air heater, as the day progresses solar intensity increases with maximum at noon. It is observed that the drying time taken to dry same quantity of product in forced convection is less than the natural convection.

The solar drying system was compared with open sun drying. A 49% saving in drying time was obtained for the solar drying system compared with that of the open sun drying.

TABLE-1

TIME OF DAY	AMBIENT TEMP. [°C]	INLET TEMP. OF DRYING CHAMBER [°C]	INLET TEMP. OF DRYING CHAMBER [°C]	EXIT TEMP. [°C]
10:00AM	35	75	75	60
11:00AM	38	80	80	69
12:00AM	40	85	85	65
1:00PM	42	90	90	70
2:00PM	38	80	80	66
3:00PM	36	75	75	60

Thermal efficiency of solar collector

$$\text{Formula } \eta = m \cdot CP \Delta T / I A C$$

$$\text{Where } m = \rho A V$$

$$\text{Velocity of air at outlet duct (v) } = 18.5 \text{ m/s}$$

$$\text{Diameter of outlet duct} = 46 \text{ mm}$$

$$\text{Area of outlet duct (A) } = \pi / 4 (d)^2 = \pi / 4 (.046)^2 = 1.66 \times 10^{-3} \text{ m}^2$$

$$\text{Density of air } = 1.2 \text{ kg/m}^3$$

$$m = 1.2 \times 1.66 \times 10^{-3} \times 18.5$$

$$m = 0.0491 \text{ kg/sec}$$

$$CP = 1.0058 \text{ KJ/Kg } ^\circ\text{C}$$

$$\text{Where solar intensity (I) } = 506 \text{ W/m}^2$$

$$\Delta T = 35^\circ\text{C}$$

$$A = 2 \text{ m}^2$$

$$\eta = m \cdot CP \Delta T / I A$$

$$\eta = [(0.0491 \times 1.0058 \times 103 \times 35) / (506 \times 2)] \times 100$$

$$\eta = 50.23\%$$

Where,

η - Thermal efficiency in %

m- Mass flow rate in Kg/sec

CP- Specific heat in KJ/Kg °C

ΔT - Difference of inlet and outlet temperature in °C

I- Solar intensity in W/m²

Ac- Area of collector in m²

A- Area of outlet duct in

V- Velocity of air at outlet duct m/s

ρ - Density of air in Kg/m³



VI. CONCLUSION

The performance of existing solar dryers can still be improved upon especially in the aspect of reducing the drying time and probably storage of heat energy within the system. Also, meteorological data should be readily available to users of solar products to ensure maximum efficiency and effectiveness of the system. Such information will probably guide a local farmer on when to dry his agricultural produce and when not to dry them.

Solar radiation can be effectively utilized for drying of agricultural produce in our environment if proper design is carried out. This was demonstrated and the solar dryer designed and constructed exhibited sufficient ability to dry agricultural produce most especially fruit items to an appreciably reduced moisture level.

It protects the environment and saves cost and time spent on open sun drying of agricultural produce since it dries fruit items faster. The fruit items are also well protected in the solar dryer than in the open sun, thus minimizing the case of pest and insect attack and also contamination.

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