Research Article

DEVELOPMENT OF LOW COST TIN SOLAR DRYER

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Abstract- Solar dryers are specialized devices that control the drying process and protect agricultural produce from damage by insect pests, dust and rain. In comparison to natural sun drying solar dryers generate higher temperatures, lower relative humidity, lower product moisture content and reduced spoilage during the drying process. In order to achieve efficient drying of material with very low cost and less maintenance this study was carried out with an objective to develop solar dryer for domestic use. In this study the performance evaluation of tin dryer was carried out. During the experimental study dryer was made up of tin box, the operational efficiency of dryer was found to be 78.95 % and maximum temperature was found 54°C with minimum relative humidity of 18%.

Keywords- Solar dryer, Temperature, Relative humidity

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Introduction

Drying is a process of removing moisture through simultaneous heat and mass transfer and is a classical method of food preservation that provides longer shelf life, reduced weight and volume. There are three phases in the drying process. The first phase is short and it is the phase during which the drying velocity increases and corresponds to the rise in temperature of the product until it reaches equilibrium. This is the time when the product receives as much heat from the air used to vaporize water. The second phase is the constant drying velocity period. It corresponds to the evaporation of the free water on the surface of the product, which is permanently renewed by the moisture coming from inside of the product. The third phase is the slowing down phase and it corresponds to the evaporation of bound water [1-5].

In industrial drying system the mechanical dryers are very popular but the cost of operation of mechanical dryer is very high which ultimately affects the production cost, therefore the efforts was taken to improve sun drying which leads to solar drying. Studies undertaken so far have clearly indicated that initial cost of solar dryers are high and the life time cost of drying is only a third of dryers based on conventional fuels. So in rural area for drying purpose such dryers are not affordable. to make drying efficient and at low cost we need an dryer of low cost and also low maintenance. Which made us to develop such type of dryer which is used at domestic level [6-10]. That is aim of our project.

The solar dryer is one of the best solutions for drying of fruits and vegetables during energy crises. Due to reduction in moisture content the shelf life of agricultural produce will increased.

Solar dryers are a very useful device for:

- Agricultural crop drying.
- Food processing industries for dehydration of fruits and vegetables.
- Fish and meat drying.
- Dairy industries for production of milk powder.
- Seasoning of wood and timber.

- Textile industries for drying of textile materials, etc.

Thus, the solar dryer is one of the many ways of making use of solar energy efficiently in meeting man's demand for energy and food supply [11-14].

Study Area

The experimental study was conducted at Department of Agriculture Process Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

Materials and Methods

A) Material used during experimental process

1) Development of dryer from oil tin box

This work was initiated with the development of tin solar dryer constructed from waste metal oil tin box. Waste oil tin box was purchased from local market cut into desired size and then painted black from outer side. In this dryer three trays were used for drying purpose which made from perforated wire mesh sheet having very small size perforations.

Materials used

1) Oil tin

An empty oil tin was purchased from local market of size 23×23×33 cm (lbt). Oil tin was in good condition means no any corrosion and having good structural strength.

2) Acrylic sheet

Acrylic is bad conductor of heat so it prevents heat leakage from drying chamber. This sheet was used to construct dryer gate so acrylic sheet of size 23×30 cm. Mainly acrylic was transparent so that it was easy to take reading of temperature by using digital hygrometer inside the dryer by constructing acrylic gate.

3) Perforated wire mesh sheet

A perforated wire mesh sheet was used for constructing trays inside the dryer. Three trays were made by perforated wire mesh sheet having size 1×3 ft. Openings on the sheet were very small.

4) PVC pipe

PVC pipe was used for construction of chimney. A PVC pipe of 2.5cm diameter and 55cm height was used.

5) Black paint

Black paint was used to paint outer size of dryer to increase absorption efficiency of solar radiation.

Fig-1 Line diagram Tin box solar dryer

6) Constructional details of tin box solar dryer

I) Drying chamber

Drying chamber of this dryer was simply constructed by oil tin box, it was cut from top side then gate of acrylic was constructed and fitted to drying chamber. In these dryer three trays was constructed so to keep these trays inside the box a metal supports were provided from inner side which was fixed with help of rivets. Construction of this dryer was in horizontal position so dimension of drying chamber was 33×23×23 cm(lbt). Drying chamber was painted black from outside and handle was fitted at top side.

II) Trays

Trays were constructed from wire mesh sheet. In this dryer three trays were constructed. Available sheet cut into three parts and metal border was fitted to sheet with help of rivets. Each tray size was 30×22 cm.

III) Chimney

Air inside drying chamber contains moisture, which have to remove so that there was necessary of air outlet at top surface. So chimney of diameter 2.5cm and height 55cm was fitted at top surface of dryer.

Plate-1 Tin dryer

B) Method followed during experimental work

A simple box type dryer was developed from waste oil tin box. The curry leaves (drying material) 78.83 g were uniformly spread in single layer over drying tray having area 0.1818m² at the morning (9.0h). The temperature and relative humidity in the cabinet was measured at equal intervals of 2 h. After the complete drying process takes moisture loss, drying efficiency and drying rate was determined by using following formula.

$$\text{Drying Efficiency} \eta = \frac{ML \times 100}{MP}$$

$$\text{Drying rate} \frac{dM}{dt} = \frac{ML}{t} \times A$$

Results and Discussion

I) Ambient air temperature and relative humidity variation:

At the time of experimental study ambient air temperature and relative humidity was measured by using digital thermometer. The temperature and relative humidity was measure at two hours interval from 9:00 to 17:00 hours. The variation in temperature and relative humidity with respect to time is given in [Table-1] and [Fig-1]. The maximum temperature (34.8 °C) and minimum relative humidity (41%) was observed at 13.00 h (mid of the day). During noon hours gradually decreasing trend in temperature and increasing behaviour in relative humidity was observed.

Table-1 Ambient temperature and Relative humidity with respect to time

Time (hrs)	Temperature (°C)	RH (%)
9:00	26.3	67
11:00	32.4	50
13:00	34.8	41
15:00	31.5	49
17:00	32.5	49

Fig-2 Temperature and Relative humidity with respect to time

II) Air temperature and relative humidity variation inside the tin dryer

From [Table-2] it shows that the temperature increases gradually with decreasing relative humidity in the cabinet dryer. This happened due to closed cabinet made by oil tin box. The maximum temperature 54°C observed at 15.00 hour and minimum relative humidity was found to be 18% which was lowest. [Fig-2] shows trend of temperature and relative humidity with respect to time.

Table-2 Temperature and Relative humidity in oil tin dryer w.r.to time

Time (h)	Temperature (°C)	RH (%)
9:00	32.0	62
11:00	44.6	29
13:00	43.6	26
15:00	54.0	18
17:00	44.9	28

Fig-3 Temperature and Relative humidity in oil tin dryer w.r.to time

Drying Efficiency and Drying Rate

The dried sample was measured (40.05g). The moisture loss was found to be 38.78 g. The dried sample was grind using domestic grinder and the powder was packed in poly bag of 200 gauge. The initial and final moisture content of sample was found to be 62.3% and 25.82%. The drying efficiency and drying rate of dryer during operation was found to be 78.95% and 0.027 kg/h-m².

Conclusion

The ambient temperature and relative humidity was found to be 34.8°C and 41% respectively after 13.00 h and inside dryer it was found to be 54°C and 18% at 15.00 h, respectively. It was observed that temperature inside the dryer was found maximum as compare to ambient temperature. The drying efficiency and drying rate was found to be 78.95% and 0.027 kg/h-m².

Application of research: Solar tin dryer is useful for small scale entrepreneurs for drying of fruits and vegetables

Research Category: Agriculture Process Engineering

Abbreviations:

% -Percentage
PVC -polyvinyl chloride
°C- Degree Celsius

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