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# HYBRID SOLAR FRUIT DRYER

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**Abstract -** *The demand for the fossil fuels is increasing day by day; hence the available sources of fossil fuels are reducing. Therefore we require an alternative energy source to fulfill our various demands. The process of removing wetness from product is understood as drying. For drying of agricultural product alternative energy is often used. It can be used most efficiently by using solar dryer, as solar dryer reduces the time required for drying and also improves quality and life of the product to be dried. There is need to develop cost effective solar dryer in which different agricultural products can be dried. Almost countries are using solar energy devices for the above mentioned activities through an individual component like, solar cooker, water heater, dryer, air heater, and solar still etc.*

***Key Words***: Solar dryer, Moisture, drying Rate, drying time, Dew point,

## 1. INTRODUCTION

Drying is one of the methods used to preserve food products for longer periods. The heat from the sun coupled with the wind has been used to dry food for preservation. The present research includes the design and manufacturing of solar fruit dryer. The use of solar energy in recent years had reached a remarkable edge. It has become more popular as the cost of fossil fuel continues to rise.

Sun drying of crops is one of the most widespread methods of food preservation in most part of India and world because of solar irradiance being very high for the most of the year. Energy in a form of solar power that is used to do many different things [13]. Among the various applications solar drying is one of the important applications. Solar dryers use the air collectors to collect the solar energy. The purpose of solar drying is to minimize the moisture content of products to a level that can prevent its spoilage.

The performance of solar dryer is dependent on incident solar radiation and atmospheric conditions. Also the design of solar dryer plays an important role in achieving require drying characteristics [1]. The inclusion of solar collector provides better performance than when products are directly exposed to sun light in solar dryer.

Farmers may find it difficult to adopt recommended technologies, because of economic problems, labour constraints, or lack of materials. To promote solar drying in India because of its potential, government is providing financial and technical assistance to the emerging entrepreneurs in this field.

### 1.1 Mechanism of drying

Drying is commonly described as the operation of thermally removing water content to yield a solid product. When a solid is subjected to thermal drying, two processes occur simultaneously [14]:
A. Transfer of energy (mostly as heat) from the surrounding environment to evaporate the moisture from the surface.
B. Transfer of internal moisture to the surface of the solid and its subsequent evaporation due to application of energy [14].
Conditions the drying behavior of agricultural crops during drying depends on the:

- Product
- Size and shape
- Initial moisture content
- Final moisture content
- Bulk density
- Thickness of the layer
- Turning intervals
- Temperature of grain
- Temperature, humidity of air in contact with the grain
- Mechanical or chemical pre-treatment
- Velocity of air in contact with the grain

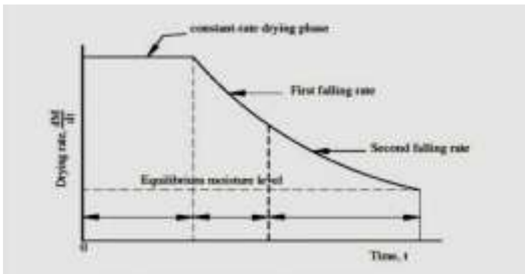


**Fig -1**: Drying rate Vs time

### 1.2 Types of Solar Drying System

#### Open Sun Drying System

This method is the most common method for drying the crops to increase their life. Drying is done by spreading the crops in a thin layer on the mat and crops are exposed to direct sunlight [7]. This method is unsuitable for large amount of crops processed by large firms.

**Direct sun drying system**

In direct type, the product is dried by directly exposed to the solar radiations. The only difference between open drying and direct drying is the product is covered with the glass. Solar radiations falls on the dryer and some of them are trapped inside the cabinet because of the glass.

**Indirect Solar Dryer**

In an indirect solar drying the heat from the sun is initially gathered by solar collectors where the air inside is get heated. This heated air is then made to flow into the dryer cabinet where drying is to be done. The heated air is passed into the cabinet by using fans. The cabinet is a closed vessel which has vent provided for removal of moist air. In an indirect type of solar dryer the quality of product is improved [11].

## 1.2 Statement of Problem

Human being's consume sun dried products in their day-to-day life from the ancient period. There are many changes in this method. These changes are mainly because of open air sun drying process [12], the products dried in the open air leads to deteriorate and contamination by dirt, insects, germs resulting poor quality of the product. By this preservation of this fruit vegetable made difficult. This made agriculture people not to grow these types of crops. This led our county to import the dry food for other country. A new method using solar drying process which more safe and user-friendly. Many local agriculture people to grow profitable crops and hygienic food. Thus the farmers need a low cost and efficient machine for drying crops. The flat collector in solar heating system plays a significant role in the quality of the circulating air. The design and development of flat plate collector has to ensure proper heating of air to the required temperature. The present work intends to investigate the performance evaluation of solar flat plate air collector with corrugated fins for fruit drying applications. The work involves experimental investigations on exit air temperature fruits data, overall efficiencies of flat plate collector and effectiveness of fins assisted flat plate collector.

**1.3 Objectives of the project**

The important objectives are below:

- To help local farmers to get high profit in the drying of crops by designing a solar photovoltaic/thermal fruit dryer.
- For Preserving of fruits, vegetables, and food and to keep them for a long time without further deterioration in the quality of the product.
- By integrating solar collector and dryer to remove moisture content of product without compromising on its nutrition value.
- To design and develop the solar flat plate collector with corrugated fin configuration.
- To analyze thermal behaviors of collector, air temperature and efficiencies for given flow velocity, mass flow rate of air, effectiveness of fins.
- To conduct experiment on the fig fruit to study its drying rate.

**2. Literature Review**

The concept of solar flat plate collector was evolved during 1760's. Later several developments have been in progress in solar collector's technologies. Several researches developed various types of collectors, to improve the thermal efficiency of the collector. In present study literature related to solar flat plate air collector with and without fins and literature related to developments in design of PV assisted flat plate collector are summarized. Many researchers have designed and developed fins in various shapes like M type, V type, honeycomb type and analyzed the effect on Reynolds number, friction factor, pressure drop etc. in most of the literature the experimental results of collector with fins were compared with experimental results of smooth duct collector, the results showed that the mass flow rate of 0.016kg/sec to 0.048kg/sec the efficiency of the collectors with fins were 10-20% more than thermal efficiency of the smooth duct collector. The exit air temperature of the collector with fins increased up to 10-25`C. The fins roughness strongly influences on the Reynolds number. Energy efficiency of the collectors were analyzed for continuous ribbed fins, the results showed the energy efficiency at lower Reynolds number. The review indicates that the exit air temperature, the heat transfer rate, pressure drop, thermal efficiency of the collector depends on fins geometric parameters like relative roughness, pitch, roughness height and angle of attack. Hence it is necessary to design fins to have higher heat transfer rate.

## 3. Experimental procedure

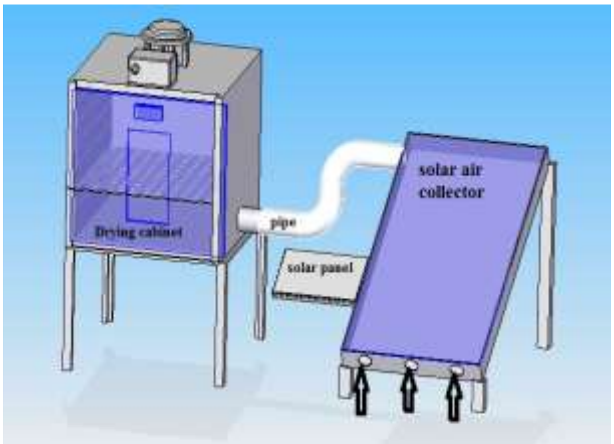


**Fig -2**: Setup of fruit dryer

The procedure for the conduction of experiments is briefly explained below which explains the step wise execution of the project.

- Assemble all the components of the solar air collectors in proper mode and connect solar air collectors with cabinet.
- Arrange K type thermocouple, contact and non contact type and data loggers in desired position and connect these instruments with electrical connections.
- Connect the fan with electricity supply.
- Measure the ambient temperature using thermocouple.
- Switch on the electrical switches connected to temperature indicator.
- Connect the controls unit for controlling dryer temperature with the battery.
- Measure the air mass flow rate using the reading of manometer connected to orifice meter.
- Simultaneously record the inlet air temperature, temperature at various points of circulating air inside the collector using K-type thermocouple and temperature indicator on hourly basis.
- Measure the weight reduction in the product.
- Calculate the, average plate temperature from the measured temperature readings and then evaluate use full heat gain, heat removal factors using properties of air in thermal data hand book.
- Evaluate performance parameters of the collector based on the measured data.
- Analyze the theoretical values with the experimental values obtained.

## 4. RESULT AND DISCUSSION

This chapter gives a detailed description of the analysis of experimental results obtained from solar dryer collector. The experimental results on performance of solar collector has been discussed in the following segments: performance of solar collector, The variations were investigated for .03 kg/s of air mass flow rates as depicted in the experimental results discussed below.

### 4.1 Analysis of collector performance

This section briefs on the performance parameter with respect to absorber plate temperature, collector efficiency, air outlet temperature, fin temperature of air under variation of isolation.

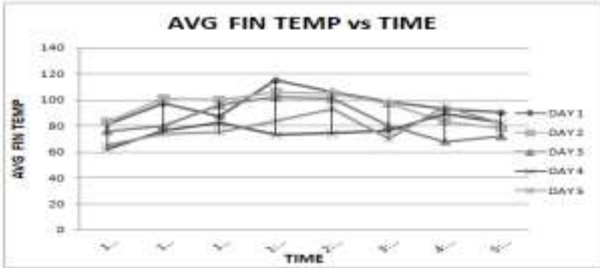


**Chart -1**: variation of fin temp with time.

Chart-1 shows the variation of the Fin temperature with the time during month of may and indicated that the Fin temperatures were higher during the period of time of 11:00 Am to 1:00 PM.

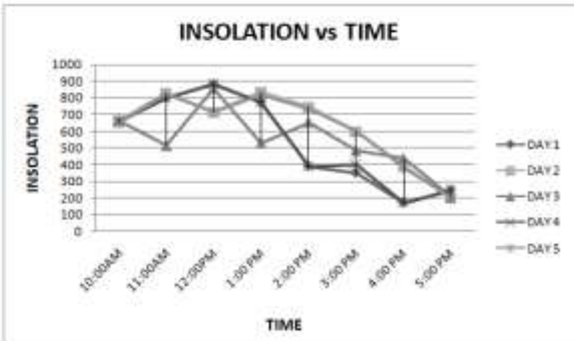


**Chart -2**: Insulation v/s Time

Chart-2 Insulation v/s Time, in May month maximum insulation is 883 and according to graph insulations is maximum at 12:00 pm. As it gradually increases from 9:00 AM to 1:00 PM, and later it decreases.

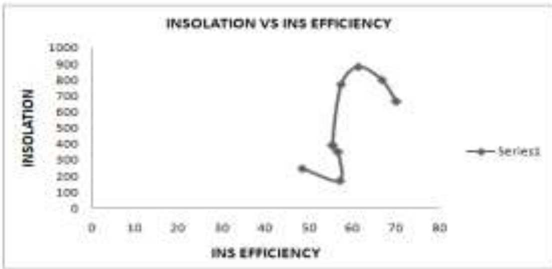

**Chart -3**: Insulation V/S Instantaneous Efficiency
Chart-3 shows Insulation V/S Instantaneous Efficiency, in May month maximum insulation is 883 and according to graph as insulation increases, Efficiency of the collector increases.

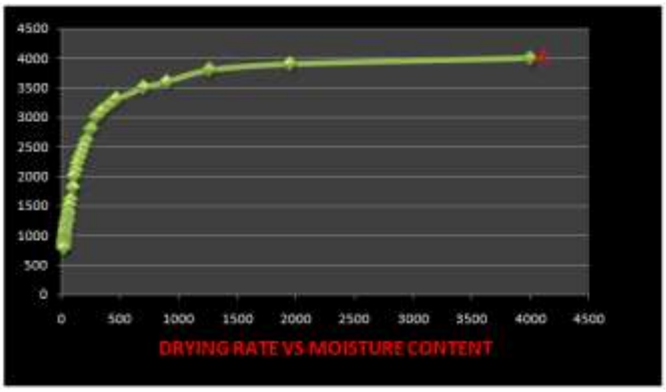


**Chart -4**: Drying rate v/s moisture content

A-B Initial adjustment period: The fruit at the beginning is exposed to air at higher temperature. So, the fruit starts getting warm, and then the rate of moisture removal is increased from A-B. Initial adjustment period is quiet small and usually ignored.

B-C Constant rate drying period: B-C is same (constant). In this case a moist fruit is placed in the stream of air; there is always a water film present on the surface of that fruit. This is because there is sufficient amount of water inside the fruit that can be easily transferred to the surface, and the surface is always covered with the layer of water. So, in this period when the water is evaporating from the surface is freely available throughout the surface of that fruit is the constant rate period.

C-D First falling rate period: In this period there is still water on the surface of the fruit but only some parts of the surface have got water film, there is just not sufficient water inside the fruit to transfer it to the entire surface to keep a water film around the entire surface as we saw in constant rate period.

D-E Second falling rate period: There are only some parts of the surface where we have water present and the rate is decreasing as that remaining water continues to evaporate from the surface. Thus we have both constant rate period and drying rate period that can be expressed on the drying rate curve.

## Conclusion

The performance valuation of solar fruit dryer indicated the following conclusions;

1. The collector can be utilizes a flexible alternative to open and dying of agricultural products and can be effectively work on the drawbacks in terms of loss in hygienic of products due to insects in infestation.

2. The maximum temperature recorded was 119 degrees for 0.03 kg/s flow rate.

3. The performance of a hybrid photo voltaic thermal (PV/T) drying system which produces both thermal and electrical energy simultaneously using a solar panel of rating 30watts. The thermal energy produced was used for the controlled drying of Fig and better drying performance was obtained compared to open sun drying

4. The closed nature of the system prevents many typical short comings of open sun drying such as microbial contamination and exposure to humid environment.

5. It is found that 70% of weight of fruit is reduced in converting raw fruit to dried fruit.

6. The efficiency of the collector is found to be 60% when the temperature is hot in condition.

## Scope of future improvements

The present work can be extended to include the following parameters,

- The optimization study on determining the suitable air gap between absorber plate and glass cover to minimize convective losses and enhance the collector efficiency
- The efficiency of the dryer can be increased by adding more than one collector.
- Induced draft type of fan fitting at the collector inlet and outlet to study the possibility efficiency enhancement.
- Study can be conducted on different fruits and crops by improving the fin design on the basis of the location.

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