Concentrated Parabolic Solar Dryer System
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Abstract:
The continuous use and frequent low of fossil fuel excited the continuous search for an alternative power source. The large amount of solar energy present at the surface of the earth. Solar is one of the renewable sources of power that attracted a large community of researchers from all over the world. This is largely due to its ample in both direct and indirect form. As such the development of efficient and inexpensive equipment for the drying of agricultural product using solar power evolved thereby increases the quality of the product as well as improving the quality of life. The use of solar dryer in the drying of agricultural products can significantly reduce or eliminate product wastage, food poisoning and at the sometime enhance the productivity of the farmers towards better revenue derived. A solar crop drying system does not solely depend on the solar energy to function. It combines fuel burning with the energy of the sun, thus reducing fossil fuel consumption. In the flat plate collector the concentrations of solar radiations were minimum and also they used glass tube for flowing the air into dryer box. This work is presenting advance technology in solar dryer using parabolic collector. In this paper advance technology in solar dryer is presented.

Keywords: Parabolic concentrated plate, Copper tube, wooden chamber, panel, thermometer, pyranometer, ginger, potato chips and chilly.

I. INTRODUCTION
Preservation of fruits, vegetables, and food are essential for keeping them for a long Time without further deterioration in the quality of the product. Several process technologies have been employed on an industrial scale to preserve food products; the major ones are canning, freezing, and dehydration. Drying is a simple process of moisture removal from a product in order to reach the desired moisture content and is an energy intensive operation. The prime objective of drying apart from extended storage life can also be quality enhancement, ease of handling, further processing and sanitation and is probably the oldest method of food preservation practiced by humankind. Drying involves the application of heat to vaporize moisture and some means of removing water vapor after its separation from the food products. In flat plate collector, A solar cabinet dryer loaded with grapes to be dried . It is a small hot box, usually made up of wood and having a length of about three times its width. The sides and bottom of the cabinet are painted black internally for absorbing solar radiation transmitted through the glass cover. Ventilation holes are provided at the bottom and holes are also provided on the upper sides of the dryer. Grapes are spread on aluminum trays, having wire mesh at the bottom and exposed to solar radiation, the temperature of grapes rises resulting in evaporation of moisture. The removal of moisture prevents the growth and reproduction of microorganisms like bacteria, yeasts and causing decay and minimizes many of the moisture-mediated deteriorative reactions. It brings about substantial reduction in weight and volume, minimizing packing, storage, and transportation costs. Drying in earlier times was done primarily in the sun, now many types of sophisticated equipments and methods are used to dehydrate foods. During the past few decades, considerable efforts have been made to understand some of the chemical and biochemical changes that occur during dehydration and to develop methods for preventing undesirable quality losses. The widest among drying methods is convective drying, i.e. drying by blowing heated air circulating either over the upper side, bottom side or both, or across the products. Hot air heats up the product and conveys released moisture to atmosphere. In direct solar drying called “sun drying” the product is heated directly by the sun's rays and moisture is removed by natural circulation of air due to density differences.

II. HISTORY
The contemporary non-conventional sources of energy like wind, tidal, solar etc. were the conventional sources until James Watt invented the steam engine in the eighteenth century. In fact, the New World was explored by man using wind-powered ships only. The non-conventional sources are available free of cost, are pollution-free and inexhaustible. Man has used these sources for many centuries in propelling ships, driving windmills for grinding corn and pumping water, etc. Because of the poor technologies then existing, the cost of harnessing energy from these sources was quite high. Also because of uncertainty of period of availability and the difficulty of transporting this form of energy, to the place of its use are some of the factors which came in the way of its adoption or development. The use of fossil fuels and nuclear energy replaced totally the non-conventional methods because of inherent advantages of transportation and certainty of availability; however these have polluted the atmosphere to a great extent. In fact, it is feared that nuclear energy may prove to be quite hazardous in case it is not properly controlled.

III. LITERATIVE REVIEW
K. S. Jairaj and S.P Singh, K. Shrikant, attempt to present various solar dryers developed exclusively for grape drying. Technical and economical results have proved that solar drying of grapes is quite feasible. Commercialization of solar drying of grapes has not gained momentum as expected, may be due to high initial investment and low capacity of the dryers. Even, the farmer’s acceptance of solar dryers
developed is not encouraging. Exhaustive research and development work has to be carried out in order to make solar drying of grapes economical and user friendly. There has been a remarkable achievement in solar drying of grapes due to sustained research and development associated with the adoption of advanced technologies [1].

Figure.1. Hybrid solar dryer system [1]

N. Rajeshwari and A Ramalingam, presents solar dryer system with multi tray rectangular section which consists of flat plate collector. In this study, temperature inside the solar box dryer and grapes moisture content with drying efficiency of grapes clusters dried in the solar box dryer have been investigated. A prototype of the dryer was constructed to specification and used in experimental drying tests. A number of experiments were conducted using potato slices, chilly and grapes. For all the test conditions, the material gets dried with system’s efficiency of 15 % to 18%. The drying time compared to open air drying was reducing by about 20% [2].

Figure.2. Effective box type solar dryer [2]

Mohammad Hanif and Mohammad Amir, a study was conducted to develop an efficient drier in the form of a dish type solar air heater that could dry grapes. A small solar air heater, connected to a drying chamber was developed at Khyber Agency (FATA), Pakistan in the month of August, 2011 for drying grapes. Efficiency of this solar air heater was evaluated in the Department of Agricultural Mechanization, Faculty of Crop Production Sciences, Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan. Two air flow rates i.e. 1 natural (0.01kg/sec) and 2 convective (0.21 kg/sec and 0.28 kg/sec) air flow rates at different day timings. The results showed that flow rates significantly (P < 0.001) affected efficiency of solar air heater. Efficiency increased from 12 percent at natural to 24 percent and 35 percent at convective air flow rates of 0.21 and 0.28 kg per second, respectively. Further, grapes were dried at temperature of 50°C and less than 20 percent humidity. Air flow rate of 0.28 kg per second was given for drying in drying chamber and grapes were dried less than a moisture content of 10 percent. It was observed that grapes were dried in 24 hours by dish type solar air heater’s drying chamber. Solar air heater also maintained the quality of grapes and minimized losses from pest attacks [3].

Figure.3. Dish type solar dryer [3]

A. Lotfalian, M.A.Ghazavi and B.Hosseinzadeh, studied drying of crops is an important procedure in order to preserve food products. The importance of it from one hand and minimizing fuel consumption from the other hand, emphasize that the designing of a system for solar drying of food is economical and substantial. Although due to increase of population industrial drying has been preferred, considering some issues such as maintaining quality, nutrition properties, marketing, and providing added value in rural societies, which lead to stable development of agriculture in a country, indicate that research and study on applying solar dryers is necessary. Regarding these issues, the process of drying of Lemon and Orange fruits by means of a passive indirect solar dryer under influence of two types of collectors (Iron and Aluminum) was studied and evaluated [4]. Ekechukwu O.V., shows a solar air flat plate collector with obstacles, it is an indirect blow-dryer system that operates in the forced convection method. The system has a solar air flat plate collector acting as a hot air maker, fan and also the microcontroller is used microwave drying is an energy-efficient drying method. Where the amount of microwave energy is determined by the ratio of “ON cycles” to “OFF cycles.” The solar collector consist a polycarbonate and transparent cover at the top, the absorber plate has made from a aluminum sheet with painted black and obstacles fixed to a thin plate are placed with an insulator of polystyrene. The collector is placed at an inclined angle of 45°. Due to the presence of obstacles maximum heat gains which fix between the cover and insulator. This maximizes the system efficiency with minimum load losses [5].

Figure.4. Solar air flat plate collector [5]
**IV. CONSTRUCTIONS**

<table>
<thead>
<tr>
<th>Table 1. Specification table</th>
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</thead>
<tbody>
<tr>
<td>Parts</td>
</tr>
<tr>
<td>Parabolic Collector</td>
</tr>
<tr>
<td>Copper tube diameter</td>
</tr>
<tr>
<td>Copper tube length</td>
</tr>
<tr>
<td>Pulley diameter</td>
</tr>
<tr>
<td>Blower</td>
</tr>
<tr>
<td>Rubber pipe diameter</td>
</tr>
<tr>
<td>Stand</td>
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<tr>
<td>Drying Chamber</td>
</tr>
</tbody>
</table>

**Figure 5. Solar dryer system using parabolic concentrated plate (line diagram)**

Solar dryer system consist of PV cell which gives 1 ampere current and which is connected to the blower having speed of 1800 revolutions per minute further blower has placed into the drum. Because of drum there are no vibrations due to blower. Blower has two openings; one is open to the atmosphere and second is connected to inlet of copper tube by means of rubber pipe. Copper tube having 410 w/m²k thermal conductivity and 0.5 inch diameter placed over the parabolic galvanized sheet with some distance between them. Galvanized sheet is attached to the pulley and wire arrangement, for giving proper angle to sheet. And lastly, outlet of copper tube is connected to the bottom of wooden box. Wooden box consist of trays in it, and has insulation to resist the heat transfer. Thermometer will be there for measuring the temperature.

**V. WORKING**

The general working of solar dryer starts with exposing the collector to the solar radiation as shown in fig [16]. The drying chamber is then filled with the agricultural goods in the area preserve for food storage. The air enters the collector and solar radiation causes the rising the temperature of air and it gets heated. This heated air removes moisture which escapes through ventilation holes on the upper side of dryers. There is more heat addition from the solar collector due to force circulation. The heated air removes moisture from the goods. The heavy air carrying moisture escapes the dryer chamber due to pressure difference. This pressure difference is also responsible for the flow of air inside drying chamber. As shown in the fig [16], the process is started from the PV cell absorb the solar radiation then convert solar energy into the electrical energy. This electrical energy used to run the blower as blower runs it suck the atmospheric air and passes through the air filter then that filter air passing through the copper tube which is placed over the parabolic galvanized sheet. Solar radiations reflects by the galvanized sheet are absorbed by the copper tube due to which copper tube gets heated and simultaneously air inside the copper tube also heated. Concentration ratio of the parabolic plate is 20:14. According to the position of sun parabolic plate is moving with the help of wire and pulley arrangement. Heated air coming from outlet of copper tube further passes to the wooden box i.e. storage box with insulation. Inside of the wooden box the trays are placed on which gingers, chilly, potato chips are dried.

**VI. OBSERVATIONS**

- Variation of Ambient and Drier Outlet Temperature against drying time.
- Variation of Solar intensity against Drying time.

**Table 2. Observation Table**

<table>
<thead>
<tr>
<th>Day</th>
<th>Sr.No</th>
<th>Solar Intensity (mV)</th>
<th>Time Hrs</th>
<th>Atm. Temp.</th>
<th>Inside Box Temp.</th>
<th>T2-T1</th>
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</thead>
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<td>44.0</td>
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<td>2</td>
<td>2</td>
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<td>1.00</td>
<td>36.4</td>
<td>45.8</td>
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<td>3</td>
<td>10.9</td>
<td>1.30</td>
<td>36.6</td>
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<td>5</td>
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<td>6</td>
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<td>47.2</td>
<td>10.8</td>
</tr>
<tr>
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<td>36.1</td>
<td>48.1</td>
<td>12.0</td>
</tr>
<tr>
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<td>2</td>
<td>10.2</td>
<td>1.30</td>
<td>36.5</td>
<td>48.2</td>
<td>11.7</td>
</tr>
<tr>
<td>Day 2</td>
<td>3</td>
<td>10.4</td>
<td>2.00</td>
<td>36.9</td>
<td>48.9</td>
<td>12.0</td>
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</tr>
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</table>

**Figure 6. Graph between Variation of Solar intensity against Drying time.**

Above graph shows variation of solar intensity against drying time. X-Axis shows the time in hours and Y-axis shows solar intensity (mV). It observed that the blue curve for the day 1 reading and green curve for day 2 reading. Curves clearly show the variation in solar intensity in day 1 reading we got maximum solar intensity as 10.9 mV and in day 2 10.8 mV.
Figure 7. Graph between Variation of ambient and inside box temperature against Drying time.
Above graph shows variation of ambient and inside box temperature against the drying time in which X-axis shows the time (in hrs) and temperature (°C) on Y-axis. The basis of observation blue curve shows the day2 reading and green curve shows the day1 reading. It observed that the difference between ambient and inside box temperature is about 9° to 10°C.

Figure 8. Vegetable Before & After Drying for potato chips

Figure 9. Vegetable Before & After Drying for chilies

Figure 10. Vegetable Before & After Drying for ginger

VII CALCULATIONS

- MOISTURE REMOVE RATE PERCENTAGE(%) [4]
  Moisture remove rate = (Original mass – Final mass)/Original mass
  Determination of moisture content
  To calculate Moisture Content:
  \[ r = 100 \left( \frac{M_w - M_d}{M_w} \right) \]
Where:
\( r \) is the percentage moisture content, 
\( M_w \) and \( M_d \) are the mass of wet and dry matter in the sample.
Where,
\( M_d \) mass of dry product, gm
\( M_w \) initial mass of wet product, gm

**Moisture content calculation [in gm]**

In Chilly = \( [(25-5) \times 100] / 25 = 80\% \)

In Chips = \( [(60-12) \times 100] / 60 = 80\% \)

In Ginger = \( [(25-10) \times 100] / 25 = 60\% \)

**Drying time**

For chilly = 7 hours
For potato chips = 6 hours
For ginger = 6 hours

**VIII. ADVANTAGES**

1. The solar dryer saves fuel and electricity.
2. Drying time in solar dryer is very less as compare to open sun drying.
3. Fruits and vegetables dried in solar dryer are hygienic as compare to open air drying.
4. Materials required for fabrication of solar dryer are locally available.
5. The use of solar dryer involves no fire hazards.
6. Less maintenance is required.
7. Low operating cost.

**IX. LIMITATION**

1. Drying rate capacity is less in rainy season and winter season.

**X. CONCLUSION**

From the study solar dryer system using the parabolic concentrated plate for multiple fruits it is conclude that it is good for drying the different agricultural goods because of mentioned advantages. It reduces the time of drying to 2-3 days. It also saves the product from birds, insects, microorganism and climate conditions. This project fabrication is achieved in reduced cost so as to make it available to common man and thus divert the attention towards renewable source of energy. The performance of an indirect forced convection solar drier integrated with blower increases air flow rate. The moisture remove rate in percentage in the chilly, potato chips and ginger is 60\%, 80\%, 60\% respectively. Economically sound farmers capable of moderate investments can choose solar dryers according to their individual requirements.

**XI. REFERENCES**


**Books:**
