A Solar Tunnel Dryer for Drying Red Chilly as an Agricultural Product

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***Abstract*—A solar tunnel dryer is commissioned at the Department of Mechanical Engineering of Kavikulguru Institute of Technology & science, Ramtek. Dryer performance is evaluated with a chimney, GI sheet and wooden frame covered with polythene for chilly drying. Chilly drying in solar tunnel dryer to reduce the moisture content from 75% to about 5% which is successfully dried. In comparison of open sun drying to obtain the same level of moisture contents resulting in saving drying time with the help of solar tunnel dryer.**

Keywords: Solar tunnel Dryer, Chilly, Moisture Content, Drying time, Temperature.

INTRODUCTION

The solar energy option has been identified as one of the promising alternative energy sources for the future. Agriculture is the main source of livelihood in India. One of the most commonly used methods for preserving foods & agricultural product is drying. Sun drying is the most widely practiced agricultural drying operation in India. The term sun drying is used to denote the spreading of the product in the sun on a suitable surface. Although sun drying is a cheap method, it often results in an inferior quality of dried agricultural products because of its independence on weather conditions and vulnerability of the products to insects, pests and microorganisms. The direct exposure to sunlight, or more precisely ultra-violet radiation, can greatly reduced the level of nutrients such as vitamins in the dried product. Open sun drying is economical and simple, it has the drawbacks like; no control over the rate of drying, non-uniform drying, chances of deterioration due to exposure of products against rain, dust, storm, birds, rodents, insects and pests which results in poor quality of dried products.

Solar drying relies, as does sun drying, on the sun as its source of energy. Solar tunnel drying can be considered as an elaboration of sun drying, and is an efficient system of utilizing solar energy. Whereas, solar drying system leads to fast rate of drying and solar dryers can generate higher air temperatures and consequential lower relative humidities, as well as lower final moisture content of the agricultural product. This method has several advantages such as less spoilage and less microbiological infestation, thus leads to improved and more consistent product quality. Joy *et al.* (2001) used a German made solar dryer to dry red chillies and they reported that only two days were taken for optimum drying of red chillies in the solar tunnel dryer whereas it took 7 to 10 days for conventional method. Mangaraj *et al.* (2001) dried punched and unpunched variety of chillies in a solar cabinet dryer and reported that it took 36 hours and 54 hours respectively to dry the punched and unpunched chillies from 300 to 8- 9 per cent (d.b). Desai *et al.* (2002) developed and evaluated mini multi rack solar dryer for fig drying and reported that the drying time required to reduce the most of fig from 77.2 per cent to 15 percent (w.b.) at full loading rate of 2.5 kg per tray was 28 hours for solar dryer while the sun drying took 42 hours.

MATERIALS AND METHODS

SOLAR TUNNEL DRYER

The solar tunnel dryer is designed, developed & commissioned at Kavikulguru Institute of Technology & Science, Ramtek of Nagpur District in Maharashtra. The solar tunnel dryer consists of different parts such as drying chamber, collector area and chimney. The drying chamber is covered with UV-stabilized polythene sheet, which is available at the local market. The solar tunnel dryer having semi-cylindrical shape for increasing absorption of solar radiation. The dryer are made to open and close easily for the functions of spreading the drying product at the beginning of the day and cleaning the absorber surface and trays. Base of the tunnel dryer is covered with thermal insulation of one inch, in order to reduce the heat loss.

Figure1. Solar Tunnel Dryer

A semi cylindrical shaped type solar tunnel dryer having a floor area of 2 ft X 6 ft is designed for drying different agricultural products (fig. 1). The solar tunnel dryer is a small poly house framed structure with UV-stabilized polythene sheet having height 1 ft, UV radiation in the sun rays may cause deterioration of active principal and also affect the texture, color and flavor of the sample so UV polythene is used. The orientation of solar tunnel dryer is in North-South direction and UV stabilized sheet of 150 micron is used as a cover material. The collector serves as a solar air heater. The absorber plate is painted black, a good absorber as well as a good emitter for radiation. In the drying chamber, a wire mesh is used as the tray material of size 2 ft X 2 ft on which drying product is spread and it is fixed at higher level above absorber plate to allow a smooth flow for the heated air. The number of trays used for drying is two. The remaining area is used as a heating area. In this area, a flow controlling unit is provided by means of a fan & wooden flap. This flap can operate outside in order to control the airflow through drying chamber.

Table 1 Temperatures, solar radiation & Air Velocity values During Drying Process

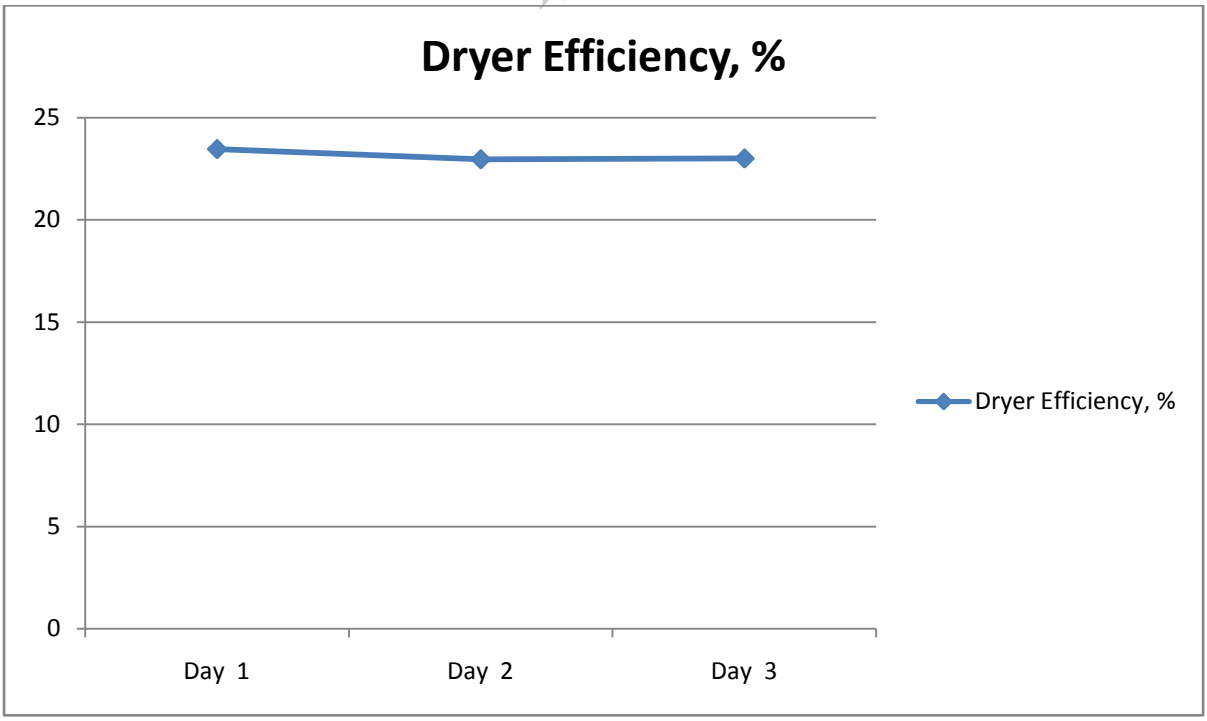
Time, Hours	Ambient Temperature, °C	Average Temperature, °C	Solar Radiation, W/m²	Air Velocity, m/s
Day 1 (03/04/2014)				
09:00	33.7	40.46	550	0.5
10:00	35.8	46.63	670	0.5
11:00	38.6	54.03	750	0.5
12:00	40.2	58.5	835	0.5
13:00	42.7	60.16	850	0.5
14:00	44.5	61.8	875	0.5
15:00	42.1	59.6	700	0.5
16:00	41.0	55.07	530	0.5
17:00	38.6	49.83	410	0.5
Day 2 (04/04/2014)				
09:00	35.3	44.3	520	0.5
10:00	37.5	48.43	670	0.5
11:00	38	52.36	800	0.5
12:00	39.4	55.56	850	0.5
13:00	40.5	59.6	900	0.5
14:00	43.0	62.9	721	0.5
15:00	39.9	61.03	590	0.5
16:00	38.5	55.66	400	0.5
17:00	36.2	48.6	300	0.5

Day 3 (05/04/2014)				
09:00	34.4	47.06	570	0.5
10:00	36.7	50.56	700	0.5
11:00	38.4	55.56	775	0.5
12:00	41.0	58.93	825	0.5
13:00	42.2	59.33	900	0.5
14:00	43.7	59.93	800	0.5
15:00	40.2	58.7	690	0.5
16:00	37.9	53.2	525	0.5
17:00	36.5	49.5	375	0.5

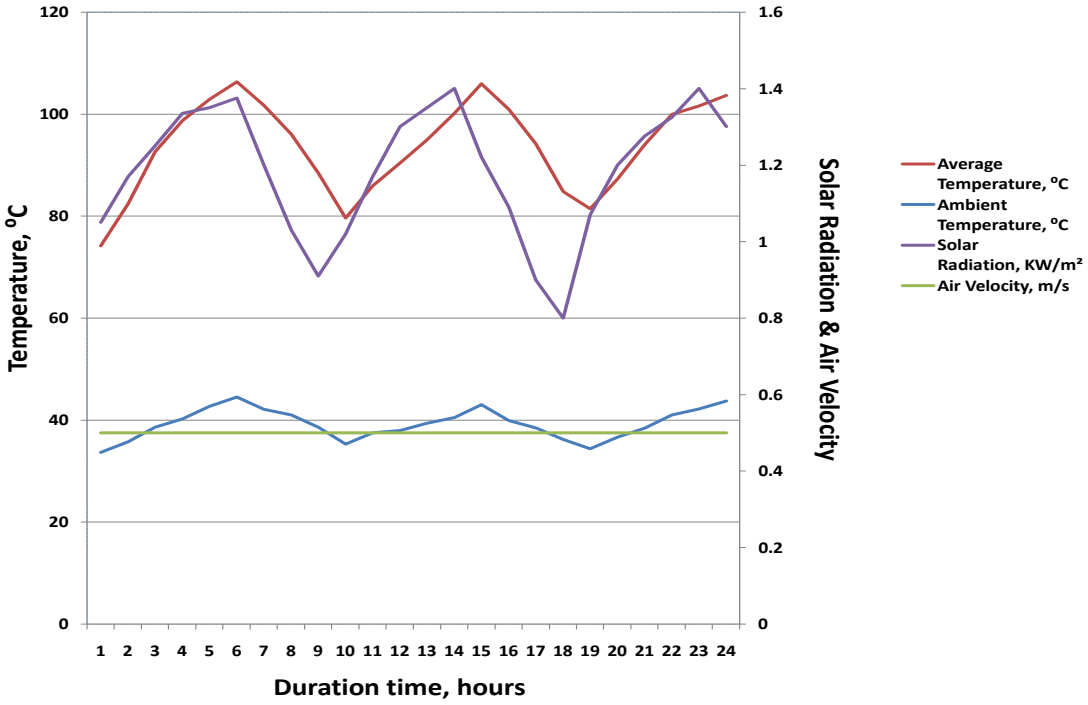
The dryer is designed to ventilate the air through natural convection with the help of chimney. Fan is providing for constant air flow. Chimney (height 3 ft made out of GI sheet) is made by rolling a thin sheet to form a cylinder and inside as well as outside of the cylinder is painted black. After installation, the performance of solar tunnel dryer is evaluated during 2014 for chilly drying at a total loading rate of 5 kg per batch and compared with open sun drying. The ambient temperature is recorded using a thermometer with an accuracy of 0.5 C. Total solar radiation is measured using a solar meter. The solar radiation is measured at interval of 1 hour. To obtain the airflow rate along the tunnel, velocity of the exit air through chimney is measured using an anemometer. The probe of the anemometer is set at the center of chimney. To find the moisture removal rate weight measurements of 5 kg of the drying product (chillies) are taken using electronic balance. An electronic balance is used to measure the weight of the total batch and the readings are obtained at the beginning and end of each day.

RESULTS AND DISUSSION

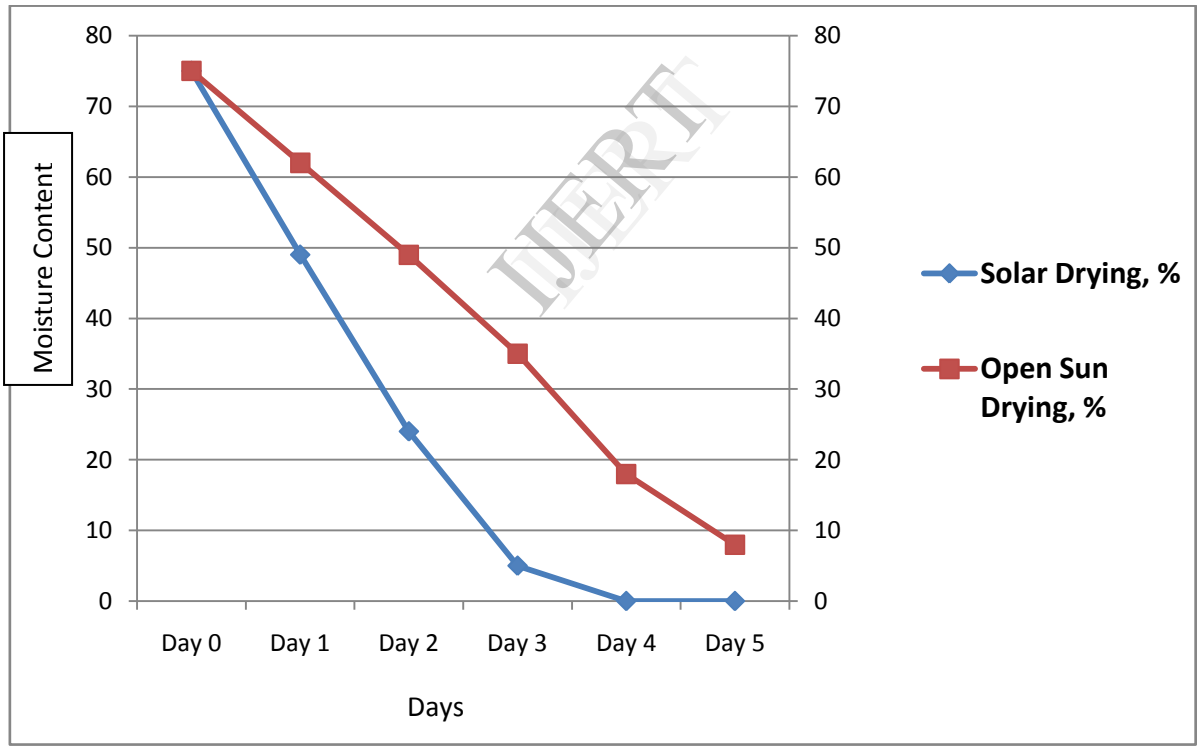
The initial moisture content in red chillies is found to be 75%. The experiment on drying chilly is conducted in the solar tunnel dryer to evaluate the performance of the dryer under loaded conditions. The dryer is loaded at 9:00 am with 5 kg of chillies, by spreading the chillies inside in a single layer. The process is continued with the required moisture content is achieved. The results pertaining to chilly drying in solar tunnel dryer are presented in following Tables & Graphs. The ambient temperature during drying period varied from a minimum of 33.7°C to a maximum of 44.5°C. The corresponding average temperature inside the solar tunnel dryer ranged from 40.46°C to 62.9°C. It is observed that the temperature achieved maximum inside the solar tunnel dryer is 30°C more than the ambient temperature at 14:00 hours. This is due to absorption of more solar energy inside the solar tunnel dryer and the prevention of heat loss from the tunnel dryer.



Graph 1 Days Vs Dryer Efficiency



Graph 2 Variations of Temperatures, Solar Radiation & Air Velocity



Graph 3 Comparison of Solar Drying with Open sun drying

On an average, a total drying time of 24 hours (3 days) are required for solar tunnel dryer to reduce the moisture content of chilly from 75% to a final moisture content of 5% while the open sun drying required on an average 40 hours (5 days) to obtain same level of moisture content which showed a net saving in drying time. This may due to higher temperature achieved in solar tunnel dryer as compared to that of ambient temperature available for open sun drying. The system drying efficiency parameter is defined as the ratio of the energy required to evaporate the moisture to the energy supplied to the dryer. The overall value for system drying efficiencies is. Thus the local solar tunnel dryer is economically and environmentally profitable and need to be popularized in rural areas of India. This dryer is suitable to dry small quantities of material (up to 5 kg) at household or farm level. Solar drying achieves higher drying rates compared with sun drying. Cost is comparatively small.

CONCLUSION

The study of project concluded for a successful solar tunnel dryer, this solar dryer is of project very important for Indian farmers as they are having small land holdings and a combination of agriculture along with small scale agriculture based entrepreneurship is the key to sustainable livelihood. Solar tunnel dryer has the potential for application in drying of various others crops like ginger, figs, pineapple, etc. as the products retain their quality, flavor and better shelf life. Solar tunnel dryer can be easily constructed using locally available materials. The fan system has an advantage of control air flow because there is a possibility of increasing relative humidity inside the drying chamber. The semi cylindrical shape solar tunnel dryer must be optimized for an efficient operation. Solar drying achieves higher drying rtes compared with sun drying.

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