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– A BRIEF RENEW

SOLAR DRYING OF FOOD MATERIALS AS AN ALTERNATIVE FOR ENERGY CRISIS AND ENVIRONMENTAL PROTECTION

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ABSTRACT

The food problem in India and most other developing countries worldwide is due largely to the inability to preserve food surpluses rather than to low production. In many countries of the world, the use of solar thermal systems in the agricultural area to conserve vegetables, fruits, coffee and other crops has shown to be practical, economical and the responsible approach environmentally. Solar heating systems to dry food and other crops can improve the quality of the product, while reducing wasted produce and traditional fuels; thus, improving the quality of life. Solar drying is an affordable and cost effective alternative for preservation of food and agricultural crops. The external heating media is not required; thus, able to overcome global energy crises. It not only save energy, but also saves time, occupies less area, improves quality of product, makes the process more efficient and protects the environment. This systemic review contain the types and application of various solar dryers for agricultural and food products in view of global energy crises. A cabinet type natural solar dryer is designed for food drying. Its construction, design parameter, applicability for food drying is also discussed in this paper.

Key words: Solar drying, Tunnel dryer, Cabinet dryer, Review.

INTRODUCTION

In many parts of the world, there is a growing awareness that renewable energy have an important role to play in extending technology to the farmer in developing countries to increase their productivity[1]. Solar thermal technology is a technology that is rapidly gaining

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acceptance as an energy saving measure in agriculture applications. It is preferred to other alternative sources of energy such as wind and shale, because it is abundant, inexhaustible and non-polluting[2-4]. Solar air dryers are simple devices to heat air by utilizing solar energy and are employed in many applications requiring low to moderate temperature below 80^{o}C, such as crop drying and space heating[5]. The application of dryers in developing countries can reduce post harvest losses and significantly contribute to the availability of food in these countries. Estimations of these losses are generally cited to be of the order of 40% but they can, under very adverse conditions, be nearly as high as 80%. A significant percentage of these losses are related to improper and/or untimely drying of foodstuffs such as cereal grains, pulses, tubers, meat, fish, etc.[6,7] Traditional drying, which is frequently done on the ground in the open air, is the most widespread method used in developing countries because it is the simplest and cheapest method of conserving foodstuffs. Some disadvantages of open air drying are: exposure of the foodstuff to rain and dust; uncontrolled drying; exposure to direct sunlight which is undesirable for some foodstuffs; infestation by insects; attack by animals; etc.[8] In order to improve traditional drying, solar dryers which have the potential of substantially reducing the above-mentioned disadvantages of open air drying; have received considerable attention over the past 20 years[6]. Solar drying may be classified into direct, indirect and mixed-modes. In direct solar dryers, the air heater contains the grains and solar energy passes through a transparent cover and is absorbed by the grains. Essentially, the heat required for drying is provided by radiation to the upper layers and subsequent conduction into the grain bed. In indirect dryers, solar energy is collected in a separate solar collector (air heater) and the heated air then passes through the grain bed, while in the mixed-mode type of dryer, the heated air from a separate solar collector is passed through a grain bed, and at the same time, the drying cabinet absorbs solar energy directly through the transparent walls or roof.

Review of types of studies conducted on solar dryers

The literature studied shows that different types of solar dryers are employed according to need of the food product. There are different types of solar drying studies conducted on different types of solar dryers and results shows that they are suitable to achieve the desired aim and able to find the drying characteristics and kinetics. In the study carried out by Ronah et al.[9], an experimental solar tent dryer under natural convection was used to study thin layer drying kinetics of amaranth (*Amaranthus cruentus*) grains. The finding shows that page model is best suited and also demonstrate the potential of using natural convection solar tent dryers to enhance harnessing of solar energy for drying amaranth grains. The study was carried out by Kamil[10], on seed pumpkin using the open sun, solar tunnel and hot air drying methods and reported that data obtained can be fitted to semitheoretical models widely used to describe thin-layer drying behaviour of agricultural products and moisture removal efficiency can be obtained up to 80%. For this purpose, there have been many studies on the solar drying behaviour of vegetables and fruits such as sweet pepper and garlic[11], tomato seed[8,12], grape[13,14], pineapple[15], Figs and onion[2], red pepper[13,7], was carried out and gave the satisfactory results. Solar tunnel drying characteristics and mathematical modelling of tomato was done by Gokhan et al.[3] They reported that new designed solar tunnel dryer can be used for various agricultural products and drying behaviour can be explained by two term model. Forced convection solar studies of *Cuminum cyminum* were undertaken by Zomorodian and Moradi[4], using direct and indirect methods and found that it gives better results as compared to natural solar convection dryer. They also found the effect of air flow rate on moisture removal efficiency and suitability of Midilli model for the drying process.

The comparative study on sour cherry was carried out by Akpinar and Bicer[5], by using solar dryer and drying under open Sun. They found that solar dryer gives better drying rate and applicable to various drying models. A solar cabinet dryer research by Mehdi Moradi and Ali Zomorodian[4], on thin layer solar drying of *Cuminum cyminum* grains was conducted, on drying rate of different drying methods as well as thermal efficiency of solar collector were obtained and reported. The effects of drying air flow rates and drying methods are highly significant on final moisture content of *Cuminum Cyminum*. Design of different of solar dryers was reported by Phoeun Sackona et al.[16] Their work include deign of solar cabinet dryer, solar box dryer, tunnel dryer and solar tray dryer for rural farmers. Solar timber drying was reported by Gan Kee Seng[17].

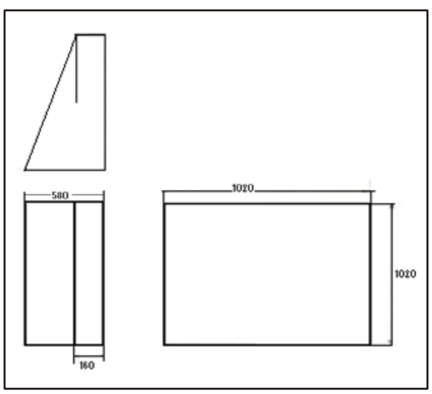


Fig. 1: Outer box

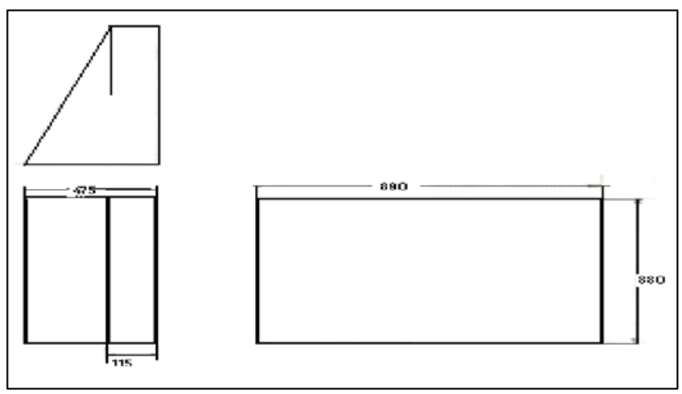
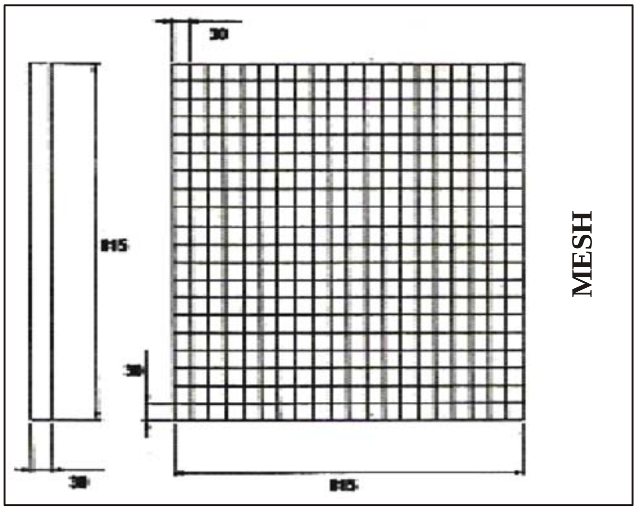


Fig. 2: Inner box



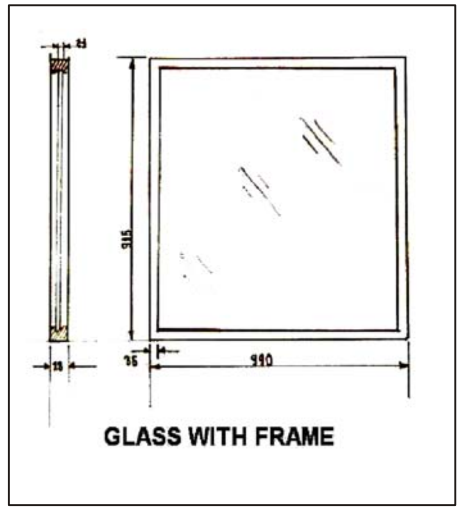


Fig. 3: Mesh **Fig. 4: Glass with frame**

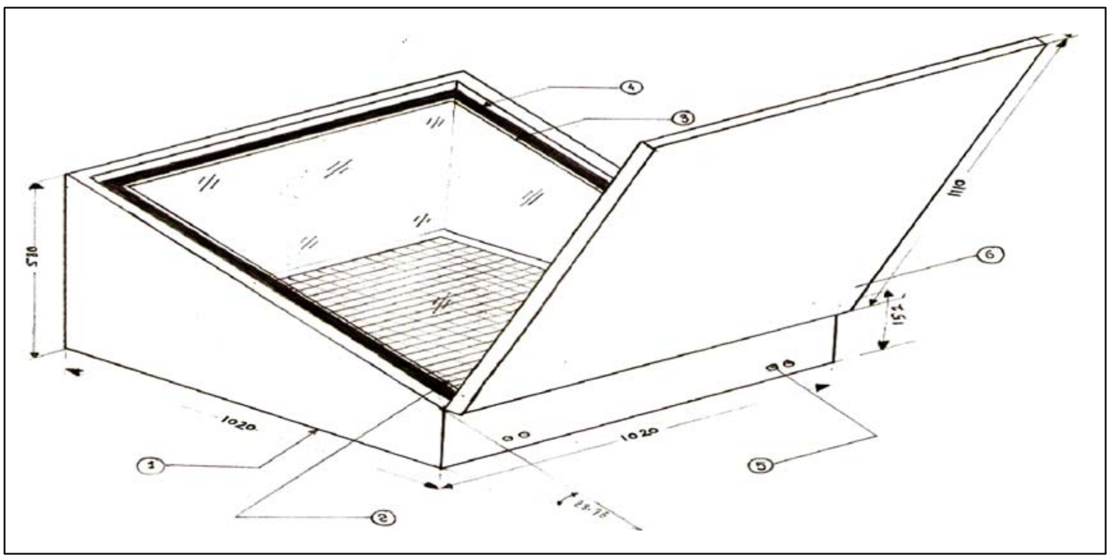


Fig. 5: Solar cabinet dryer (1-Box, 2 Mesh, 3-Glass, 4-Glass frame, 5-Holes)

These studies were generally specific design and were basically carried out to determine the solar drying time as compared to air drying and to demonstrate its viability at various sites. Design, construction and testing of simple solar maize dryer was carried out by Joshua F. et al.[18], and in conclusion, the need for the construction of a solar dryer arose as an alternative to ordinary sun-drying technique. Mohamed Ayoub et al.[19], designed and constructed a solar dryer for mango slices and found that the dryer can be effectively used to dry mango slices under controlled and protected conditions. An advanced solar dryer for salt recovery from brine effluent of desalination plant was developed by Pedro et al.[20], which results in an optimized evaporation area and suitable for brine recovery. Technical and financial evaluation of a solar dryer in Bhutan was done by Fuller et al.[21] and they reported that the benefit cost ratio is less than unity. This is due to the improper design and high cost of collector plate. A solar-biomass hybrid tunnel dryer was designed and fabricated by Gauhar et al.[22] Efficiency of the dryer during its two mode of operation has been estimated and compared with other similar dryers. Considerable reduction in drying time is the major advantage reported with this hybrid dryer. The facilitating of continuous year-round operation of the dryer and the 60-80% reduction in drying time in comparison with open sun drying and solar drying, increases the utilisation of the dryer, and improves the financial viability of the tunnel dryer considerably. Ching and Abdul[23], studied the quality of cocoa beans dried using a direct solar dryer at different loadings and found that overall quality assessment showed that the 20 kg treatment was able to produce reasonably good-quality beans as compared to other loadings and therefore, it is recommended for the direct solar dryer.

EXPERIMENTAL

Design of cabinet type solar dryer

The solar dryer considered in this research paper is cabinet type solar dryer, suitable for small scale use. The dryer consists of an enclosure with a transparent cover. The material to be dried is placed on perforated trays. Solar radiation entering the enclosure is absorbed in the product itself and the surrounding internal surfaces of the enclosure. As a result, moisture is removed from the product and the air inside is heated. Suitable openings at the bottom and top ensure a natural circulation. Temperature ranging from 50 to 80°C is usually attained and the drying time ranges accordingly. Typical products, which can be dried in such devices are ginger, dates, apricots, chillies, grapes. Here the product is located on bottom mesh inside drying chamber. Solar radiation is thus not incident directly on the crop but through the mirror. Dryer is made up of the following basic units:

(a) Drying chamber

The drying chambers is made of a highly polished plywood box held in place by angle irons. The material has been chosen since wood is a poor conductor of heat and its has smooth surface finish; heat loss by radiation is minimized. To further reduce heat loss by radiation and to avoid moisture absorption by the wood, aluminium foil is wrapped on the inside of the chamber.

(b) Cover plate

This is transparent sheet used to cover the absorber, thereby preventing dust and rain from coming in contact with the absorber. It also retards the heat from escaping (i.e. forming a confinement for heated air). It is placed about 25.4 mm above the absorber. Common materials used for cover plates are glass, flexi glass, fibre glass, reinforced polyester, thin plastic films and plastics.

(c) Absorber plate

This is a metal plate painted black and placed about 25.4 mm below the cover to absorb the incident solar radiation transmitted by the cover; thereby, heating the air between it and the cover. In its plainest form; it is no more than a blackened metal plate exposed to the sun.

(d) Insulator

This is used to minimize heat loss from the system. It is placed under the absorber plate. The insulator must be able to withstand stagnation temperature, should be fire resistant and not subjected to out-going gassing; and should not be damageable by moisture or insect. Insulating materials are usually fibre glass, mineral wool, styrofoam and urethanes.

(e) Reflector (with rubber casing)

Reflection is the change in direction of a wave front at and between two different media so that the wave front returns into the medium, from which it originated. Common examples include the reflection of light, sound and water waves. Here mirror is employed as a light reflector. The reflector of dimensions 1.020 x 1.110 m has been employed in order to collect all the wave fronts from the source (Sun) and to emit them on the required media with the proper intensity. The reflector has been designed in such a way that the angle of reflector is adjustable with the change in the position of the heat source (Sun).

Assembly

A vertical cabinet solar dryer is a simple steel sheet type material box of certain width and length (3 x 3 feet). As the figure shows the outside and inside surface of the dryer is painted black because the heat absorbing capacity of the black body is maximum and the product to be dried are kept on the trays made up of wire mesh bottom. The loaded trays are kept through an openable door provided on the top side of the dryer. The PBC glass (4 mm) at an angle 24 degree with the horizontal provided on to 6 inch from the bottom and the holes are provided at the bottom. Most of the dryer through, which moist warm air escaped, when the food product is placed on the trays exposed to warm air, the temperature of the product rises resulting in evaporation of the moisture.

Testing

The testing of the solar cabinet dryer can be done in the bright sunny day. The solar dryer can be placed outside with the collector facing the direction of the sun. The collector has been rigidly fixed to the dryer at an angle approximately 10^o to the horizontal to obtain approximately perpendicular beam of sun rays to avoid damage in transit. About 10 kg of freshly harvested material can be feed in the drying chamber evenly distributed on the mesh. The fresh air can be suck automatically from the bottom. Due to the black body, the inside temperature of the body is increased, therefore fresh air will gets warm and it flows from bottom to top as it gets lighter than the fresh air. The moist air is escaped from the product. The warm air is passed through holes by natural convection, creating the partial vacuum and fresh air up through the bottom gap. The drying time can be reduced from 1/2 to 1/3 as compared to open sun drying.

CONCLUSION

The need for the construction of a solar dryer arose as an alternative to ordinary sun-drying technique. Solar drying is found to be effective for food drying as the drying temperature requirement is not too high. Different types of solar dryers can be constructed according to requirement of drying materials. In the present study, a cabinet type solar dryer was designed and constructed for agricultural products. The maximum temperature attained by the dryer on bright sunny day was found to be 80^oC in the month of December. The detail study of drying characteristics, effect of various parameters and operating conditions, validation of various drying models can be done and commercial viability of the dryer can be tested.

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