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Experimental Model Investigations of Solar Drier System

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ABSTRACT—People have been using this source since many years now. In this paper, an attempt is made to review various aspects of solar driers applied to drying of food products at small scale. Solar energy is the one of the oldest source of energy in the world. It is freest and cleanest source of energy because it has no destructive effect on environment. Popular types of driers in Asia-Pacific region, and new types of driers with improved technologies are discussed. The open sun drying and some alternate solutions are presented. The various aspects considered for modeling and experimental investigations carried out on various food products are also presented. Finally, the performance evaluation of the drier is discussed in detail. It is found that there is a shorter way of estimating the performance of a drier.
Index Terms— Sun Drying, Solar Drier, Clean Energy, Performance Evaluation.

I. INTRODUCTION

The solar radiation saved for 40 days is enough to cope up the energy needs for one century. By using solar radiation with the solar energy, fossil fuel for coming generations can be saved. Food is the basic and most necessary need of human beings. The biggest problem faced by the human race is the consumption and production of food. The two solutions require a considerable amount of money and time to achieve. A third solution and a important one to this world's food problem includes reduction of food loss which happens mainly in developing countries due to less marketing channels, improper transportation, high post harvest losses etc., causing the loss in food about 10 to 40% [1]. The food preservation is the method to reduce the food loss and drying which is been in use since many centuries. 50% of wet vegetables are removed as waste while cooking [2]. If vegetables are peeled and the peels are dried, the peels can be used to feed animals. Also, water is removed during drying; a lot of fuel can be saved during transportation of dry vegetables when compared to wet vegetables. The drying of various products is explained in detail and some ideas which can be useful for promotion of driers in the Indian context. More than 80% of the food produced in developing countries is by small farmers. These farmers commonly dry the food under direct sunlight. Except that solar energy is available in abundance, there are many disadvantages of natural sun drying process. The drying process of various products is explained in detail [3] and also some ideas on promotion of usage of driers to the Government and common public are suggested. Some of the disadvantages include degradation due to debris in wind, rain, insect, infestation, rodents, birds, over/under drying, etc. Further, due to long time drying, there is a risk of aflatoxin contamination of cereal grains. The drying of paddy, fruit, timber and cash crops are explained [4] in Indian context. In other words the quality of the finished production is poor. Apart from the quality there exists some cases where natural sun drying cannot be employed, e.g. cardamom cannot be sun dried as the sun will fade the green color. The process of drying is explained briefly. There are several disadvantages with the natural sun drying process. Some of the demerits include [5] degradation due to windblown debris, rain, insect infestation, rodents, birds, over/under drying, etc. Further, due to prolonged drying, there is danger of aflatoxin [6] contamination of cereal grains. In other words the quality of the finished product is poor. Apart from the quality there exist some strange cases where natural sun drying cannot be adopted, e.g., cardamom cannot be sun dried as the sun [7] will fade the green color. At the start of the drying process the food produced contains moisture, and its moisture content is same as the surface: this is phase I. The moisture is present as on a free water surface [8]. This is a surface evaporation phenomenon. As the surface product dried up, moisture has to migrate from the interior to the surface, where it can be evaporated: this is phase II. The energy required for this process is more important than it is for surface evaporation. It is a surface phenomenon. The phase depends upon particular food produced. The influence of temperature is very important for this process, as there exists a maximum allowable temperature for every product, which is 15-20 C higher than the ambient temperature [9]. In case of sun drying, the solar radiation heat is used to evaporate the moisture present in the product. As the sunshine is intermittent and varying, the product may over/under dry. Hence, this energy is used to heat large volume of air and this air is allowed to hover over the products to remove the moisture and also take away. Such a equipment which uses solar energy to heat air and hence dry the products is called Solar Drier [10-16]. A solar drier minimizes almost all the problems faced during natural sun drying, thus improving the quality of dried product.

Different types of solar driers are available in the market depending upon their uses like direct solar drier, Indirect solar drier, mixed and hybrid solar drier. Fig. 1 shows the schematic of different solar drier system currently in used for different purposes.

II. WORKING OF SOLAR DRIER

It is based on the greenhouse effect where the solar heat is trapped inside the drying chamber and thus increases the temperature level. It is mixed-mode solar cabinet dryer. Here both direct and indirect solar energy collected in the chamber heats up the food products. The direct solar energy collected in the chamber converted into heat energy heats up the food product and thus removes moisture from the food product. The indirect heat energy collected in the solar collector heats up the fresh air entering from atmosphere through air inlet and is pass through the bottom of the drying chamber and it collects the moisture from the food products and exhausted through air outlet. It is fully based on natural phenomenon. No mechanical and electrical energy are applied. Here fresh air having atmosphere temperature enters the dryer at the bottom end of the solar collector and leaves at the upper most portion of the drying chamber through exhaust air outlet. The essence of keeping solar energy absorbing portion at an inclination of 210° is because, most of the research found that at this angle absorption of solar radiation is maximum.

III. EXPERIMENTAL SETUP

For the design being considered the greenhouse effect and thermo siphon principles is the theoretical basis. There is an air vent (inlet) with guide ways to the solar collector where air enters and is heated up by the greenhouse effect, the hot air rises through the drying chamber passing through the trays and around the food, removing the moisture content and exists through the air vent (or outlet) near the top of the shadowed side. Mirrors are attached to allow and bound the heat inside the chamber. Provisions are made to shift the angle of mirror attachments.

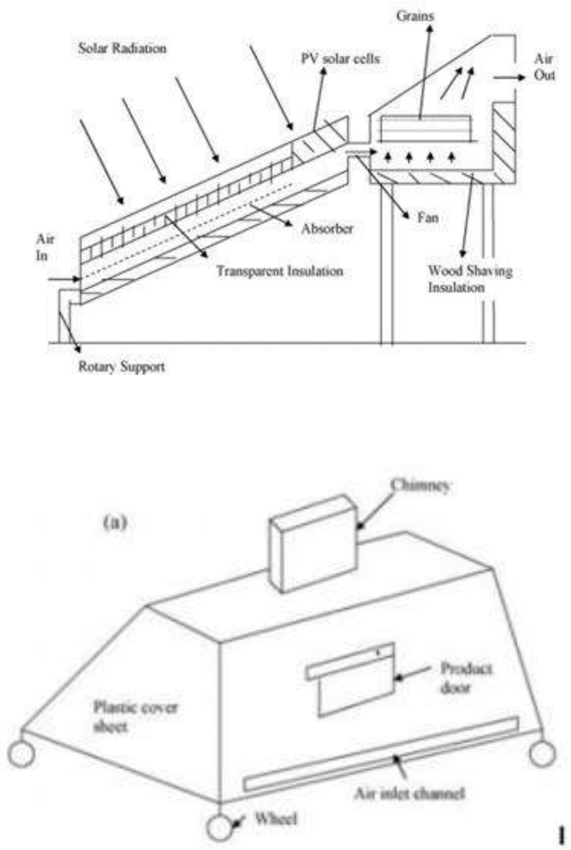

Fig. 1 Schematic of different types of solar configurations used [19]

IV. RESULTS AND DISCUSSION

After course of study we have found that the low cost solar cabinet dryer gives more than three times heat inside the chamber than that of the outside atmospheric temperature. In 7 hours continuous drying under the same climatic condition and same time it removed 48.72 % (upper tray) and 33.03% (lower tray) moisture content from inside chamber chili whereas at outside only 15.38% moisture content was removed. The results obtained during the test period revealed that the temperature inside the dryer and solar collector were much higher than the ambient temperature during most hours of the daylight). The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product.

The dryer is hottest about mid-day when the sun is usually overhead. The temperatures inside the dryer and the solar collector were much higher than the ambient temperature during most hours of the daylight. Fig. 2 shows a typical day results of the hourly variation of the temperature in the solar collector and the drying cabinet compared to the ambient temperature.

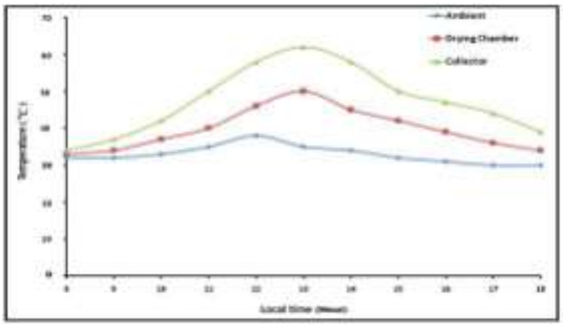

Fig.2 Temperature variation with variation in time in conventional solar

Fig.3 shows the diurnal variation of the relative humidity of the ambient air and drying chamber. Comparison of this figure with Fig.4 shows that the drying processes were enhanced by the heated air at very low humidity.

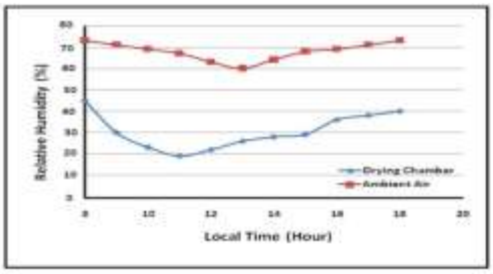

Fig.3 Diurnal variation of relative humidity in the dryer

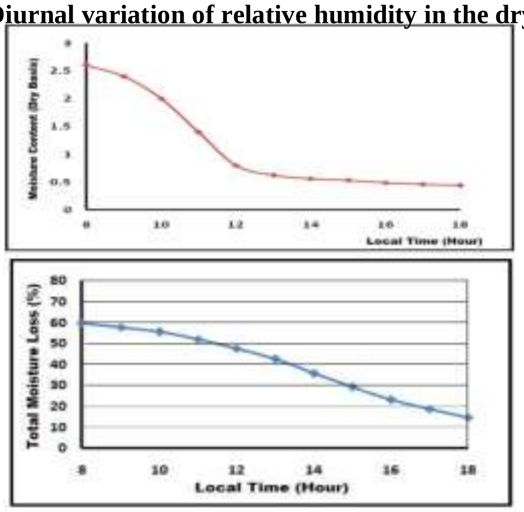

Fig.4 Drying of food grains in the dryer

Fig 4 shows the moisture content and loss in the food grains when dried in the designed solar drier. The dehydration of food products is considered to calculate the quantity of air needed for drying, depth of food bed, height of chimney and pressure difference across the food bed. Psychrometry is used to determine the thermal energy to be removed for drying cassava to desired moisture level. Considering a bed of cassava the area of collector and the depth of the bed is calculated for the drying process. A drier is constructed with sensible type rock storage system to continue the drying process in the nights. The temperature, humidity and variation of moisture content are plotted with respect to time on a given day for cassava leaves. The drying process is described by an empirical equation. The drying constants for constant- and falling-rate periods [17, 18] are tabulated for cassava chips, pepper and groundnuts.

CONCLUSION

Numerous types of solar drying systems have been designed and developed in various parts of the world. Improving of the drying operation to save energy, improve product quality as well as reduce environmental effect remained as the main objectives of any development of solar drying system. Solar dryers have been proposed to utilize free, renewable, and non-polluting energy source provided by the sun. The materials used for the construction of the mixed-mode solar dryer are cheap and easily obtainable in the local market. The post-harvest losses of agricultural products can be reduced drastically by using well designed solar drying systems. Drying time is less in forced convection than the natural convection. So forced convection is preferred than natural convection for drying of agricultural products. The overall cost and choice of materials would promote mass production and hence, it can be a substitute to the expensive conventional dryers thereby making it assessable and affordable by local farmers. The temperature rise inside the drying cabinet was up to 24^{o}C (74%) for about three hours immediately after 12.00 (noon). The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and simultaneously it ensures a superior quality of the dried product.

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