

Design And Development Of Solar Seed Dryer

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Abstract: Solar energy is the most promising of the renewable energy sources in view of its apparent limitless potential. Direct solar energy has been applied to grain drying for years. The sun and wind dry crops in the field, stack or windrow. Artificial drying has supplemented this process to increase the harvest rate during inclement weather or to minimize field losses. This article investigates solar grain drying as one alternative. Radiant energy from the sun reaching the earth surface is known as shortwave radiation, solar radiation, solar energy or isolation. The total radiation may be direct from the sun; diffuse, scattered by the atmosphere or reflected, from adjacent surfaces.

A small scale village level solar dryer for tomato was developed under Yola weather at latitude 9°14' N and longitude 12°26' E using locally available materials and the performance was evaluated. On the similar approach we manufactured seed dryer which is also more useful for drying the seeds, crops i.e. maize, beans etc. The essence of the dryer was to achieve the effective method of seed preservation and eliminate the drudgery and product deterioration associated with traditional methods of open sun drying of seed. This is in view of alleviating the weather limitation experienced by farmers in crop drying especially for tomatoes. The solar dryer consists of tray, reflective walls and glass roof, a preheating air absorber plate, inner panels for removal of moisture and chimney through which air stream passes across the dryer. Evaluation of the dryer showed a raised temperature of about 47° attainable in the drying chamber. The dryer temperature and drying rate was found to be higher than the natural open sun drying method. The results showed a considerable advantage of solar dryer over the traditional open sun drying method in term of drying rate and less risk for spoilage.

Keywords: Solar dryer, Moisture content, Temperature, Village level.

I. INTRODUCTION

Food drying is a very simple, ancient skill. It is one of the most accessible and hence the most widespread processing technology. Sun drying of fruits and vegetables is still practiced largely unchanged from ancient times. Traditional sun drying takes place by storing the product under direct sunlight. Sun drying is only possible in areas where, in an average year, the weather allows foods to be dried immediately after

harvest. The main advantages of sun drying are low capital and operating costs and the fact that little expertise is required. The main disadvantages of this method are as follows: contamination, theft or damage by birds, rats or insects; slow or intermittent drying and no protection from rain or dew that wets the product, encourages mould growth and may result in a relatively high final moisture content; low and variable quality of products due to over - or under-drying; large areas of land needed for the shallow layers of food; laborious since the crop must be turned, moved if it rains; direct exposure to sunlight reduces the quality of some fruits and vegetables. Moreover, since sun drying depends on uncontrolled factors, production of uniform and standard products is not expected. The quality of sun dried foods can be improved by reducing the size of pieces to achieve faster drying and by drying on raised platforms, covered with color or netting to protect against insects and animals. Due to the current trends towards higher cost of fossil fuels and certainty regarding future cost and availability, use of solar energy in food processing will probably increase and become more economically feasible in the near future.

Solar dryers have some advantages over sun drying when correctly designed. They give faster drying rates by heating the air to 10-30°C above ambient, which causes the air to move faster through the dryer, reduces its humidity and deters insects. The faster drying reduces the risk of spoilage, improves quality of the product and gives a higher throughput, so reducing the drying area that is needed. However care is needed when drying fruits to prevent too rapid drying, which will prevent complete drying and would result in case hardening and subsequent mould growth. Solar dryers also protect foods from dust, insects, birds and animals. They can be constructed from locally available materials at a relatively low capital cost and there are no fuel costs. Thus, they can be useful in areas where fuel or electricity are expensive, land for sun drying is in short supply or expensive, sunshine is plentiful but the air humidity is high. Moreover, they may be useful as a means of heating air for artificial dryers to reduce fuel costs. Solar food drying can be used in most areas but how quickly the food dries is affected by many variables, especially

the amount of sunlight and relative humidity. Typical drying times in solar dryers range from 1 to 3 days depending on sun, air movement, humidity and the type of food to be dried.

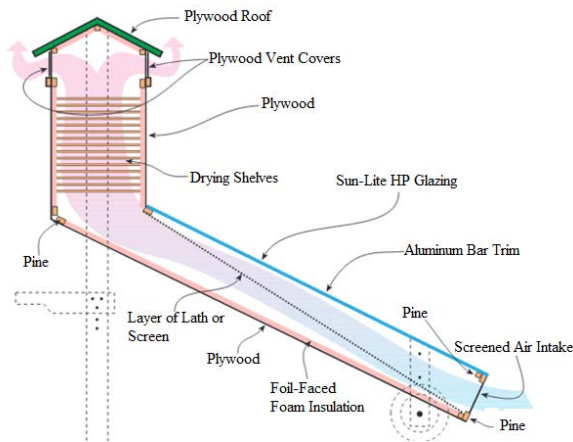


Figure1. General Working of Solar Dryer

Fig1. shows the schematic representation of General Working of Solar Dryer. The principle that lies behind the design of solar dryers is as follows: in drying relative and absolute humidity are of great importance. Air can take up moisture, but only up to a limit. This limit is the absolute (maximum) humidity, and it is temperature dependent. When air passes over a moist food it will take up moisture until it is virtually fully saturated, that is until absolute humidity has been reached. But, the capacity of the air for taking up this moisture is dependent on its temperature. The higher the temperature, the higher the absolute humidity, and the larger the uptake of moisture. If air is warmed, the amount of moisture in it remains the same, but the relative humidity falls; and the air is therefore enabled to take up more moisture from it's surrounding. To produce a high-quality product economically, it must be dried fast, but without using excessive heat, which could cause product degradation. Drying time can be shortened by two main procedures: one is to raise the product temperature so that the moisture can be readily vaporized, while at the same time the humid air is constantly being removed. The second is to treat the product to be dried so that the moisture barriers, such as dense hydrophobic skin layers or long water migration paths, will be minimized.

Direct drying consists of using incident radiation only, or incident radiation plus reflected radiation. Most solar drying techniques that use only direct solar energy also use some means to reflect additional radiation onto the product to further increase its temperature. An example of direct absorption dryer is the hot box dryer . The aim of this type of a dryer is

mainly to improve product quality by reducing contamination by dust, insect infestation, and animal or human interferences. It consists of a hot box with a transparent top and blackened interior surfaces. Ventilation holes in the base and upper parts of slide walls maintained a natural air circulation. For the solar mode of operation, it was found that the dryer reduced the moisture content of a typical batch of fresh pineapple slices from 669 % to 16% (on dry basis, db) in 5 days, with the daily intensity of global solar radiation varying from 18.4 to 26.8 mj m^{-2} on an inclined plane (16° to the horizontal). It should also be mentioned that the drying product was not removed every day from the dryer after sunset because the stored thermal energy enable drying to proceed at night. So, the dryer can be exclusively powered by solar energy to dehydrate a fresh food to the required level of moisture under favorable weather conditions. The drying chamber has the shape of a parallel piped with its longitudinal axes in the North-South direction. A wooden frame supports a transparent polycarbonate hollow plate 4.5 mm thick. The wooden skeleton and polycarbonate plates are screwed together allowing the whole chamber to be disassembled easily. The construction is modular to permit variations of the drying chamber capacity. Trays have a shape that they can be piled easily without crushing the fruits and allow air circulation between them following the main axis. Four small windows located at the far ends of the chamber enable introduction of measuring devices and also control the air renewal in the system. Eight fans placed inside the chamber produce and internal recycling, and cause the air flux to be uniform. The drying system has six solar collectors made of blackened iron plate, protected by a glass cover, which also helps to decrease heat losses

II. LITERATURE REVIEW

Grain drying Grain drying is process of drying grain to prevent spoilage during storage. Overview Hundreds of millions of tonnes of wheat, corn, soybean , rice and other grains as sorghum, sunflower eds , rapeseed /canola, barley , oats ,etc., are dried in grain dryers[1]. In the main agricultural countries, drying comprises the reduction of moisture from about 17-30%w/w to values between 8 and 15%w/w, depending on the grain. The final moisture content for drying must be adequate for storage. The more oil the grain has, the lower its storage moisture content will be (though its initial moisture for drying will also be lower). Cereals are often dried to 14% w/w, while oilseeds, to 12.5% (soybeans), 8% (sunflower) and 9% (peanuts)[2].

The drying process has been experimentally studied and analyzed to simulate and design a drier. As

drying is a process of removing moisture to a safe level, the equilibrium moisture content is defined as the moisture content in equilibrium with the relative humidity of the environment. The equilibrium moisture content is divided into, static and dynamic. While the static is used for food storage process, dynamic is used for drying process. The drying process is experimentally obtained and presented as moisture content on x-axis and rate of drying on y-axis. A deep bed of food grains is assumed to be composed of thin layers normal to the hot air flow direction. The equations for thin layer were written initially, using empirical, theoretical and semi theoretical equations. The conditions of the grain and air, change with position and time during drying of a deep bed of grains. Logarithmic and partial differential equation models to simulate the deep bed dry modeling are dealt in detail (Murthy, 2009).

The drying chamber of a drier consists of meshes on which product is spread for drying. Also, the drying chamber (Youcef-Ali et al., 2004) is a wooden cabinet. Hence, the heat loss to the side walls of the drying chamber is considered. As the hot air passes through the mesh, in forced convection driers, turbulence is created. A solar drier without either heat storage or air recycling is considered with a solar collector containing offset plate fins. Experiments are conducted to calculate heat losses (through Nusselt number).

The change of main variables such as moisture content along the drying tunnel is considered unlike in previous works where uniform distribution is assumed (Condori and Saravia, 2003). This is a study of tunnel green house drier which is continuous type. The conditions for improvement of efficiency are evaluated. A linear relationship between the tunnel output temperature and incident solar radiation is obtained. The drier production is presented by a performance parameter which is defined as the ratio between the energy actually used in the evaporation and the total available energy for the drying process. A non-dimensional variable is also defined, which has all the meteorological information. It is found that, the average moisture content value of the tunnel can be considered to be constant (Murthy, 2009).

The solar tunnel drier is modified to develop a green house tunnel drier whose working principle and construction is explained in detail. Some additional features of the tunnel drier are high lighted such as improvement in the drier efficiency, lowering of the labor cost and ease in installing a conventional heater as an auxiliary heating system for continuous production (Condori et al., 2001). The drier is considered as a solar collector, and its instantaneous efficiency is measured.

Products were dried in various configurations, i.e., cut in various ways. The plots of time in a given day vs. moisture content are plotted.

Through out the literature, decrease in drying time has been the main concern. Further, the natural convection type drier is not preferred as low buoyancy forces may cause reverse effect leading to the spoilage of the product. In order to resolve these two issues, an integral type natural convection drier coupled with a biomass stove is developed. The constructional details and operation of the drier are presented in detail. Drying time was lowest for solar-biomass method. The uniformity of drying was questionable as there was significant variation in moisture content when samples were tested from trays at top, middle and bottom. Even within a tray, when temperature, relative humidity and velocity of air were measured, variations were observed. The drying efficiency of the drier was evaluated and it is noted that, type of product and its final moisture content level influences the drying efficiency. The final moisture in a product generally requires more energy to extract than the initial moisture and the preparation of the products prior to drying such as slicing, boiling affects the drying efficiency. These factors make it difficult to make comparisons with the drying efficiencies of other solar driers reported in the literature.

III. WORKING OF SOLAR SEED DRYER

Drying is the process of moisture removal from the product, or grain in this case. Since grain is a hygroscopic material which can either absorb or desorb moisture from the air or its surroundings depending on the difference in vapour pressure, moisture transferred from a higher vapour pressure, to the lower one. In the sun drying process, grain is heated by solar radiation thus creating a higher vapour pressure in grain than the surrounding air. In the same manner, the heated air drying process starts when the grain is heated (by conduction) when it comes in contact with the air. Higher velocity air flow in heated air drying has the advantage of reducing the boundary layer of the grain, thereby increasing the heat transfer coefficient of the grain, as well as increasing the rate of moisture movement from grain to the surrounding air. Therefore, the drying rate of a specific kind of grain is dependent on both air temperature and air flow rate.

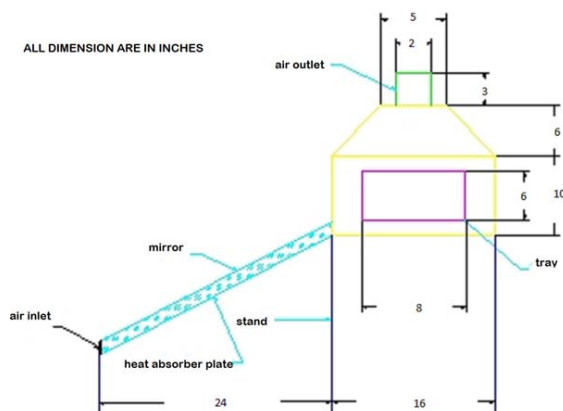


Figure2. Two Dimensional Representation of Solar Seed Dryer

The actual systematic representation of solar seed dryer with dimension is as shown in fig. 2. Sun drying of leaves, flower, fruits, vegetables, roots and tubers requires the application of the following principles:

- Catching as much as possible of sun radiation by appropriate absorbers (black plates perpendicular to the sunbeams)
 - Increasing the circulation of air around the product
 - Avoiding heat loss (insulation of areas not exposed to the sun)
 - Avoiding direct sun radiation of the product since this affects the appearance adversely (discoloration).
 - Protecting dried product against: Rehydration, Dust contamination, Harmful effect of light
- Drying starts at the bottom of the bin, which is the first place air contacts. The dry air is brought up by the fan through a layer of wet grain. Drying happens in a layer of 1 to 2 feet thick, which is called the drying zone.
 - The usual drying times range from 1 h to 4 h depending on how much water must be removed, type of grain, air temperature and the grain depth.
 - Counter flow dryers may be found on-farm, adapting a bin to slowly drying grain fed at the top and removed at the bottom of the bin by a sweeping auger.
 - The drying zone moves from the bottom of the bin to the top, and when it reaches the highest layer, the grain is dry. The grain below drying zone is in equilibrium moisture content with drying air, which means it is safe for storage.
 - Preparation of the raw material for food consumption (washing, sorting, peeling ...) to avoid spoilage
 - Protecting raw material against loss of quality during the drying process (blanching against enzymatic action)
 - Facilitating fast drying by increasing the exposed surface of the products (dicing' slicing' spreading-out of products)

Table 1 shows, the humidity and temperature content of different type of grains. Similarly Table 2 shows, the moisture content for dry basis and wet basis.

Table 1. Humidity and Temperature Content

Grain	Relate Humidity (%)							
	30	40	50	60	70	80	90	100
	Equilibrium Moisture Content (%wb) at 25 ^o C							
Barley	8.5	9.7	10.8	12.1	13.5	15.8	19.5	26.8
Shelled Maize	8.3	9.8	11.2	12.9	14.0	15.6	19.6	23.8
Paddy	7.9	9.4	10.8	12.2	13.4	14.8	16.7	-
Milled Rice	9.0	10.3	11.5	12.6	12.8	15.4	18.1	23.6
Sorghum	8.6	9.8	11.0	12.0	13.8	15.8	18.8	21.9
Wheat	8.6	9.7	10.9	11.9	13.6	15.7	19.7	25.6

Table 2. Moisture Content

Moisture content- Dry basis (%)	Moisture content- Wet basis (%)
400	80
300	75
200	67
100	50
50	33
25	20
15	13
10	9.1

IV. RESULT AND DISCUSSION

Drying is carried out as a requisite for safe storage, in order to inhibit microbial growth. However, low temperatures in storage are also highly

recommended to avoid decreative reactions and, specially, the growth of insects and mites. A good maximum storage temperature is about 18°C. The largest dryers are normally used "Off-farm", in elevators, and are of the continuous type: Mixed-flow dryers are preferred in Europe, while Cross-flow dryers in the United States. Continuous flow dryers may produce up to 100 metric tonnes of dried grain per hour. The depth of grain the air must traverse in continuous dryers range from some 0.15 m in mixed flow dryers to some 0.30 m in Cross-Flow. Batch dryers are mainly used "On-Farm", particularly in the United States and Europe. They normally consist of a bin, with heated air flowing horizontally from an internal cylinder through an inner perforated metal sheet, then through an annular grain bed, some 0.50 m thick (coaxial with the internal cylinder) in radial direction, and finally across the outer perforated metal sheet, before being discharged to the atmosphere.

The usual drying times range from 1 h to 4 h depending on how much water must be removed, type of grain, air temperature and the grain depth. Grain drying is an active area of manufacturing and research. The performance of a dryer can be simulated with computer programs based on mathematical models that represent the phenomena involved in drying: physics, physical chemistry, thermodynamics and heat and mass transfer. Most recently computer models have been used to predict product quality by achieving a compromise between drying rate, energy consumption, and grain quality.

A typical quality parameter in wheat drying is bread making quality and germination percentage whose reductions in drying are somewhat related. Drying starts at the bottom of the bin, which is the first place air contacts. The dry air is brought up by the fan through a layer of wet grain. Drying happens in a layer of 1 to 2 feet thick, which is called the drying zone. The drying zone moves from the bottom of the bin to the top, and when it reaches the highest layer, the grain is dry. The grain below drying zone is in equilibrium moisture content with drying air, which means it is safe for storage; while the grain above still needs drying. The air is then forced out the bin through exhaust vent. Allowable Storage Time Allowable storage time is an estimate of how long the grain needs to be dried before spoilage and maintain grain quality during storage. In grain storage process, fungi or molds are the primary concern. Many other factors, such as insects, rodents, and bacteria, also affect the condition of storage.

V. CONCLUSION

This work is focused on the available solar dryer's systems and new technologies. The dependence

of the drying on the characteristics of product remains still as a problem, for comparison of drying efficiencies of various driers. In this work we design and developed the Solar Seed Dryer. Also details of construction and operational principles of the wide variety of practically realized designs of solar-energy drying systems present. Two broad groups of solar-energy dryers can be identified, viz., passive or natural-circulation solar-energy dryers and active or forced-convection solar-energy dryers (often called hybrid solar dryers). Three sub-groups of these, which differ mainly on their structural arrangement, can also be identified, viz integral or direct mode solar dryers, distributed or indirect-modes. This classification illustrates clearly how these solar dryer designs can be grouped systematically according to either their operating temperature ranges, heating sources and heating modes, operational modes or structural modes. Though properly designed forced-convection (active) solar dryers are agreed generally to be more effective and more controllable than the natural-circulation (passive) types. Such low-cost drying technologies can be readily introduced in rural areas to reduce spoilage, improve product quality and overall processing hygiene.

REFERENCES

1. Fellows, P. Guidelines For Small-Scale Fruit and Vegetable Processor s, FAO Agricultural Services Bulletin 127, FAO of the United Nations, Rome, 1997.
2. Boiln, H. R., and Salunkhe, D. K. Food Dehydration by Solar Energy, CRC Critical Reviews in Food Science and Nutrition, , pp:327-354, April 1982.
3. Szulmayer, W., From Sun-Drying to Solar Dehydration I and II, Food Technology in Australia, ,pp: 440-501, September 1971.
4. Rossello, C., Berna, A., and Mulet, A., Solar Drying of Fruits in a Mediterranean Climate, Drying Technology, 8 (2), pp: 305-321, 1990.
5. Schirmer, P., Janjai, S., Esper, A., Smitabhindu, R., and Mühlbauer, W., Experimental Investigation of the Performance of the Solar Tunnel Dryer for Drying Bananas, Renewable Energy, Vol. 7, No. 2, pp: 119-129, 1996.
6. Narinesingh, D., and Mohammed-Maraj, R., Solar Drying Characteristics of Papaya (Carica papaya) Latex, Journal of the Science of Food and Agriculture, 46, pp: 175-186, 1988.

7. Kaptan, H., and Seylam, A., Solar Drying of Selected Fruits and Vegetables, Unpublished, TUBITAK-MRC, FSTRI, 1996.

8. Agate, E., Fencing: a practical handbook. Doncaster, British Trust for Conservation volunteers, BTCV Enterprises, 2001.

9. Ker, A.D.R., Moorse, M.W., Watts, E.R. & Gill, B.N. Agriculture in East Africa, London, Edward Arnold Ltd.

10. Leighton, J. 1978. Guide to fencing. Supplement to the New Zealand Farmer, April 27, 1998.

11. Midwest Plan Service, Beef housing and equipment handbook. 4th edition. Ames, Iowa, 1987.

12. Okongo, E., Movable fence design using bamboo. Unpublished dissertation. Department of Environmental and Bio-systems Engineering, University of Nairobi, 2009.

13. Roberts, M., Farm and smallholder fencing: A practical to permanent and electrical livestock fencing on the farm and smallholding. UK, Gold cockerel books, 2009.

Design was based solar water heater of 100lpd configuration and detailed drawings were prepared using Unigraphics NX 10.0.

Fabrication process involved different materials, according to design specifications. The first to be fabricated were the copper trays

(24G). [2] Mangesh Gavhale et al, "Design and development of solar seed dryer", ijiset volume 2 issues 4, april 2015. [3] Ashish D. Chaudhari, "A review of solar dryer technologies", international journal of research in advent technology, volume 2 february 2014. [4] Anupam Tiwari, "A review on solar drying of agricultural produce", journal of food. Project Done By Ullas U, Tej Kiran G, Sandeep D , Valleesh B , Dr. Kiran Kumar P. Previous. A small scale village level solar dryer for tomato was developed under Yola weather at latitude $9^{\circ}14'$ N and longitude $12^{\circ}26'$ E using locally available materials and the performance was evaluated. On the similar approach we manufactured seed dryer which is also more useful for drying the seeds, crops i.e. maize, beans etc.

@inproceedings{Gavhale2015DesignAD, title={Design And Development Of Solar Seed Dryer}, author={Mangesh Gavhale and Swapnil Kawale and Ramesh Nagpure and V. N. Mujbaile and Neha S. Sawarkar}, year={2015} }. Mangesh Gavhale, Swapnil Kawale, +2 authors Neha S. Sawarkar. Solar energy is the most promising of the renewable energy sources in view of its apparent limitless potential. Solar dryers are devices that use solar energy to dry substances, especially food. There are two general types of solar dryers: Direct and indirect. Direct solar dryers expose the substance to be dehydrated to direct sunlight. Historically, food and clothing was dried in the sun by using lines, or laying the items on rocks or on top of tents. In Mongolia cheese and meat are still traditionally dried using the top of the ger (tent) as a solar dryer. In these systems the solar drying is assisted by the