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Different Drying Methods for Agriculture Products and Eatables – A Review

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Abstract: **This paper describes the various methods of drying technologies that can be used for drying agricultural products and eatables. Normally these methods are used in different types of usages, drying range, drying quality, quantity, conventional and renewable sources, drying time, etc. based on the requirement to use the type of drying methodology to produce quality of products. Natural convection method is normally used to produce quality of agricultural products and related details are discussed in this review paper.**

Keywords: Drying, STD, OYSD

1. INTRODUCTION

In India large amount of copra is produced. The coconuts are used for different types of purposes like food, oil, etc. One of the coconuts' product, copra is produced for different purposes. Ayyappan and Mayilsamy [1] described the fresh copra has moisture content is 52% (wet basis). But we required to producing dried copra in 7% moisture content. In this purpose people used different types of drying methods like Natural convection methods, Electrical methods and Mechanical methods. In natural convection methods have different types; one of the Solar Tunnel Dryer (STD) methods is effectively used to dry the copra. The STD was taking less duration for drying moisture content from copra. In open yard sun dryer is taking more duration to reduce the moisture content in copra and not produce the quality and non clean less products. The paper reviews various solar methods with a special focus on solar drying techniques, as they are most economically viable solar dryer methods are used and thus most suitable for drying agriculture products. Emily F. Shanahan et al [2] showed several potentially confounding environmental variables were recorded during the sampling periods, and included atmospheric pressure, humidity, rainfall, solar exposure, and temperature. These data were provided by the Australian Bureau of Meteorology Station (040861) located at the Maroochydore Airport, about 5km from the STP.

2. DRYING METHODS

Fig. 1 shows the detailed classification of drying methods, which are of relevance to regions of world.

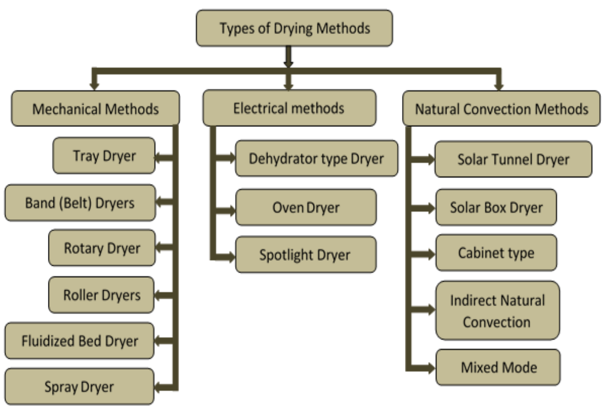


Fig. 1. Drying methods.

3. MECHANICAL METHODS

3.1 Tray Dryer

Tray dryers (Fig. 2) are classified as batch type and band dryer and can dry almost everything. However, because of the labors required for loading and unloading, they are expensive to operate. They find most frequent application when valuable products like dyes and pharmaceuticals are involved.

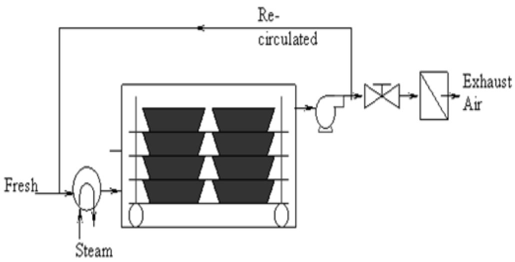


Fig. 2. Tray Dryer.

This type of dryer is frequently used for drying of wood and various agricultural products.

3.2 Band (Belt) Dryers

A band dryer (Fig. 3) is preferable if the particles to be dried are rather coarse (i.e. between 5 to 10 mm). The particles spread evenly into slowly moving, e.g. 5mm/s, perforated belt. The belt moves into a drying cabinet and warm gas passes downward through the layer. This type of dryer is chosen when it is not possible to suspend the particles in the drying gas. The dryer must offer a residence time, say 15min, because bound moisture must defuse through the pellet.

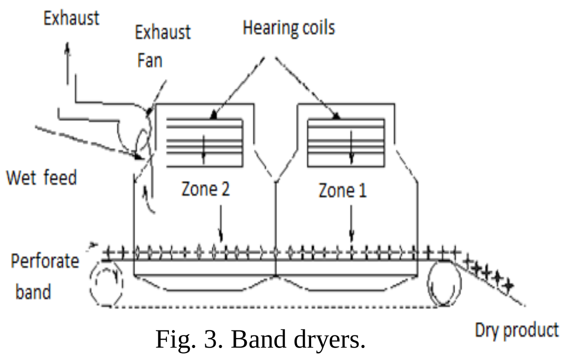


Fig. 3. Band dryers.

3.3 Rotary Dryer

The rotary dryer (Fig.4) consist of a cylindrical shell, horizontal or slightly inclined toward the outlet.

They are heated by

a) Direct contact of air or gas with the solids,

b) By hot gasses passing through an external jacket on the shell, or,

c) By steam condensing in a set of longitudinal tubes mounted on the inner surface of the shell.

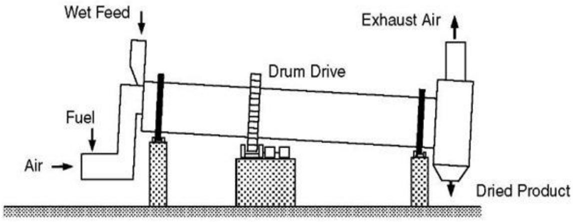


Fig. 4. Rotary dryers

The product is fed to the upper orifice and transported during mixing through the cylinder. Regardless of the method of the heating, the water is removed with the air. The disadvantage of rotary dryers is the big power losses, which occur if the product is fine grained. The installation of the particle/ gas separation at the moist air outlet (e.g. cyclones) may reduce the product losses significantly.

3.4 Roller Dryer

A roller dryer consist of a cylinder, heated from the inside by stream. A thin film of the product is sprayed on the outside of the cylinder and it is heated while the cylinder rotates. The rate of drying and the final water content in the product is affected by the

a) Rotational spread of the roller,

b) Steam pressure,

c) Thickness of the film, and

d) Properties of the product.

Owing to the sort contact time in combination with high drying temperature, the roller dryer is well adapted to heat sensitive products. Typical applications are fabric drying in textile industries and paper band drying in paper mills.

Hitesh N Panchal & Dr. P. K. Shah [3] explained on the glass thickness lower glass cover thickness increases distillate output from solar still, i.e. 4 mm glass cover thickness produces more distillate output compared with 8 mm as well as 12 mm. Lower glass cover thickness decreases inner glass cover temperature inside solar still, i.e. 12 mm glass cover thickness produces highest inner glass cover temperature compared with 4 mm as well as 8 mm thickness of glass cover.

3.5 Fluidized Bed Dryer

In a fluidized –bed dryer (Fig. 5), the particles are fluidized by air or gas in a boiling bed unit. The average time a particle stays in a bed is usually between 30and 60s. If fine particles are present, there may be considerable solids carried over with the exit gas, and cyclones and bag filters are needed for their recovery.

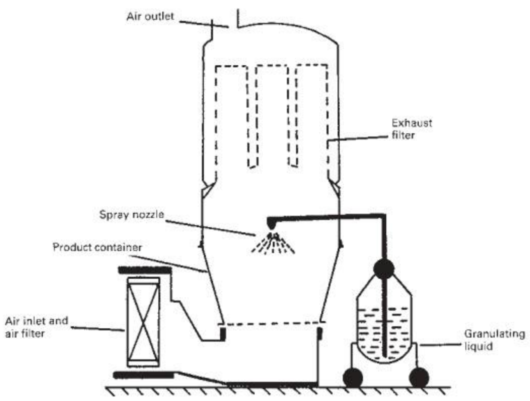


Fig. 5. Fluidized bed dryer

3.6 Spray Dryers

The pneumatic or 'flash' dryer is used with products that dry rapidly owing to the easy removal of free moisture or where any required diffusion to the surface occurs readily. Drying takes place in a matter of seconds. Wet material is mixed with a stream of heated air (or other gas), which conveys it through a drying duct where high heat and mass transfer rates rapidly dry the product. Applications include the drying of filter cakes, crystals, granules, pastes, sludges and slurries; in fact almost any material where a powdered product is required. Salient features are as follows.

1 Particulate matter can be dispersed, entrained and pneumatically conveyed in air. If this air is hot, material is dried.

2 Pre-forming or mixing with dried material may be needed feed the moist material.

3 The dried product is separated in a cyclone. This is followed by separation in further cyclones, fabric sleeve filters or wet scrubbers.

4 This is suitable for rapidly drying heat sensitive materials. Sticky, greasy material or that which may cause attrition (dust generation) is not suitable. The type of spray dryer is normally Pneumatic / Flash dryer is shown in (Fig. 6).

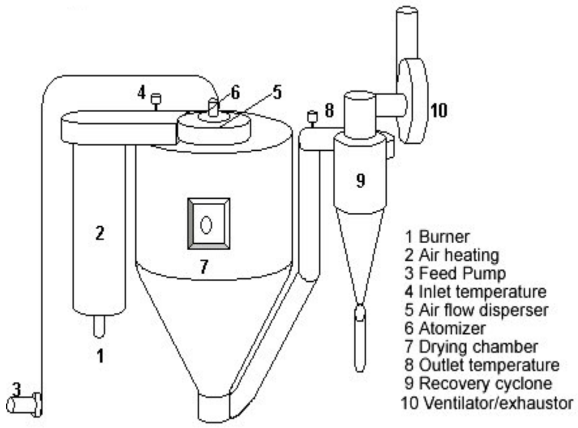


Fig. 6. Spray Dryer

4. ELECTRICALMETHODS

4.1 Dehydrator Dryer

A dehydrator dryer (Fig. 7) is dehydrating food is an ancient method of preserving food. It is a gentle, natural process which removes moisture from food. Using a controlled heat temperature, air is circulated from the top of the unit to each of the five trays and base. This method of drying seals in the flavor sand nutrients of the food, leaving a high food nutrient and vitamin content.

Natural healthy snacks can easily be created using your Food dehydrator. A variety of fruit rolls such as pear, berry and apple rolls, to name a few. You can make tasty, muesli bars, using all natural ingredients.

Fig. 7.Dehydrator dryer

4.2 Oven Dryer

Oven drying (Fig. 8) is the simplest way to dry food because you need almost no special equipment. It is also faster than sun drying or using a food dryer. But oven drying can be used only on a small scale. An ordinary kitchen oven can hold only 4 to 6 pounds of food at one time. Set the oven on the lowest possible setting and preheat to 140 degrees F. (60 C.). Do not use the broiler unit of an electric oven because the food on the top tray will dry too quickly' Remove the unit if it has no separate control. Some gas ovens have a pilot right, which may keep the oven warm enough to dry the food.

Fig. 8. Oven Dryer

It is important to keep the oven temperature at 140 to 160 F. (60 to 70 C.). So put an oven thermometer on the top tray about half way back where you can see it easily. Check the temperature about every half hour. Arrange 1 to 2 pounds of prepared food in a single layer on each tray. Put one tray on each oven rack. Allow 1-1/2 inches of space on the sides, front, and back of the trays so that air can circulate all around them in the oven. To stack more trays in the oven, use blocks of wood in the comers of the racks to hold the trays at least I inches apart. Dry no more than four trays of food at a time. A lighter load dries faster than a full load. Keep the oven door open slightly during drying. A rolled newspaper, a block of wood, or a hot pad will keep the door ajar so that moist air can escape while the heat stays in the oven. Four to six inches for electric ovens or 1 to 2 inches for gas ovens is usually enough space for ventilation, but use a thermometer to check the oven temperature to make sure it stays at 140 F. An electric fan placed in front of the oven door helps to keep the air circulating. Shifting the trays often is important for even drying because the temperature is not the same everywhere in the oven. Rotate the trays from top to bottom and from front to back every half hour. It helps to number the trays so you can keep track of the order in which you rotate them. Stirring fruit or vegetables every half hour or so also helps the food to dry evenly.

4.3 Spotlight Dryer

Manjula et al [4] proposed laboratory experiments contain the spotlight drying method shown in (Fig. 9). The study shows that there is an inverse relationship between air temperature and drying time. The air temperatureas radiation intensity is an influential external parameter which is not the case of air velocity. Drying curves do not clearly indicate the effect of air velocity on drying time, and there is an inverse relationship between radiation intensity and drying time. Taking into account the evaporation process of water, abetter understanding of drying phenomena was achieved by determining internal conductance C(X) and D(X).

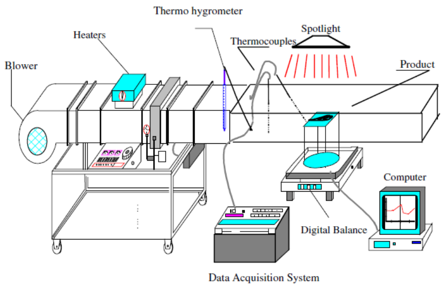


Fig. 9. Spotlight dryer

No expression of C(X) and respectively D(X) with air velocity can be seen. Future work can be done designing and measuring drying experiments on a higher scale to better validate the results.

However, the laboratory model could satisfactorily represent the drying of red peppers in large ranges of air temperature, air velocity and incident radiation. The statistical analysis confirmed the suitability of the established model. The laboratory model does not roughly predict the drying data for open sun and greenhouse conditions because the drying operation presents inertia to variation of external parameters. To adjust predictions of the drying process under time varying conditions a correction factor in time was introduced in the formulation of the model. The corrected model could adequately describe the thin layer drying behavior of red peppers in open sun and greenhouse conditions. The methodology adopted in this particular drying process may be applied to different agricultural products as well. Models of this nature are applicable to the study and simulation of greenhouse type-solar dryers.

5. NATURAL CONVECTION METHODS

5.1 OYSD (Open Yard Sun Drying Method)

In OYSD, we are simply drying the products in open atmospheric space. Due to this the chances of products getting affected due to rain and dust are more. There is also a possibility fungus formation of the products if they are kept as it is.

5.2 Solar Tunnel Dryer

In natural convection method different types of solar dryers are used based on the quantity and time. Solar drying is a continuous process where moisture content, air and product temperature change simultaneously along with the two basic inputs to the system i.e. the solar isolation and the ambient temperature.

Fig. 10. Solar Tunnel Dryer

The solar tunnel dryer (Fig. 10) consists of dryer comprises a plastic sheet-covered flat plate collector and a drying tunnel. The drying rate is affected by ambient climatic conditions. This includes: temperature, relative humidity, sunshine hours, available solar isolation, wind velocity, frequency and duration of rain showers during the drying period [1].

Open sun drying of various industrial and agricultural products is being practiced since age. Open sun drying is slow and exposes the produce to various losses and deterioration in quality. A number of industries have, therefore, accepted mechanical drying of the produce. Fuel wood, petroleum fuel, coal or electricity is used for air heating in the mechanical dryers. Solar air dryers have great potential for replacement of industrial scale drying of industrial and agricultural products. Besides, effecting saving of precious fossil fuel, fuel wood or electricity, the solar drying may also is cost effective.

Joy c.m. and K.P. Jose [5] explained solar dryers in comparison with open sun drying gave better quality products with lesser drying time (Patil1989). Kamaruddin et al. (1994) have developed a method for the drying of pepper using solar energy. Pruthi (1989) had shown a drying time of 8 hours for 30-40 tones of pepper when dried in a mechanical dryer imported from Holland. To improve the overall quality of pepper, a solar dryer and some additional appropriate technologies were used to produce pepper of a high microbiological standard, deep black col› our and low humidity (Ahlert et at. 1997). The quality of black pepper is assessed by its aroma and pungency retained after drying. The pun› gency of pepper is due to the presence of piper› ine.

Fig. 11 Solar Tunnel Dryer

Oparaku, n.f [6] explained about solar tunnel dryer (Fig. 11) model performance at 10% residual error interval was 78.4 and 83.3%, respectively, for global solar radiation and plenum chamber temperature. Linear relations existed between the simulated and mean of satellite global solar radiat ion, and simulated and actual plenum chamber temperature. The correlation between the simulated and satellite solar radiation was strong since the coefficient of determination was high (R^2 =0.788). S.

A.S.M.Mohsin et al [7] explained about daily solar radiation varies between 4 and 6.5 kWh/m2.In this regard, solar dryer for domestic as well industrial usage could be an effective alternative of saving conventional energy. Utilization of solar thermal energy through solar dryer is relatively in a nascent state in Bangladesh**.**

5.3 Mixed Mode Dryer.

G. M. Kituu et al [8] discussed about mixed mode natural convection of solar dryer integrated with a simple biomass burner and bricks for storing heats. The dryer was designed for small-scale commercial producers of agricultural products in non-electrified locations. From a series of evaluation trials of the system, the capacity of the dryer was found to be 60–65 kg of unshelled fresh harvested groundnuts. The drying efficiency of the solar component alone was found to be 23%. While, the efficiency of the burner with heat storage in producing useful heat for drying was found to be 40%.The key design features of the dryer contributed to produce an acceptable thermal efficiency, and uniformity of drying air temperature across the trays, were the jacket and gap enclosing the drying chamber and arranged bricks for storing heats.

S. Janjai et al [9] described the solar radiation passing through the polycarbonate roof heats the air and the products in the dryer as well as the concrete floor. Ambient air is drawn in through a small opening at the bottom of the front side of the dryer and is heated by the absorber and the products exposed to solar radiation. The heated air, while passing through and over the products absorbs moisture from the products. Direct exposure to solar radiation of the products and the heated drying air enhance the drying rate of the products.

A. A. Zomorodian and M. Dadashzadeh [10] showed the moisture ratio decreases with a diminishing rate at different air flow rates and for two solar drying systems. This means that all drying periods were performed in the falling rate period. These results are in good agreement with the results of other researchers who had some extensive research on the solar drying of different products such as pistachio, chilli, crapes etc. [11] The performance of the solar dryer depends on several factors, the solar radiation, inlet air temperature of solar dryer and the dryer design factors note that access to the highest temperature required for drying when tray 4 is from 61°C and is at the highest intensity of the radiation 700 W/m^2 at 11. There were no significant differences in temperature at the trays (1, 2 and 3) with the differences ranging from (2 to 5°C).

B. K Bala et al [12] proposed the solar tunnel drier was installed at the yard of the workshop of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh. The drier was placed on raised platform. Mushrooms used for solar drying were collected from the local markets of Mymensingh and Savar. Three tests on solar drying of Mushrooms were carried out at Bangladesh Agricultural University, Mymensingh in the month of May in 2007 and in the month of March and May in 2008.

Mohod A.G et al [13] showed during winter season (Fig.3), the average temperature inside solar tunnel dryer was found to be 50.39°C with corresponding relative humidity 11.92 % which was the lowest value. The corresponding ambient temperature, relative humidity and solar intensity were found to be 33.97°C, 14.38 %, 445.58 w/m^2 respectively. The maximum average temperature inside the solar tunnel dryer was found to be 52.41°C at center of solar tunnel dryer followed by north side (51.06°C) and south side (47.69°C). The minimum average relative humidity inside the solar tunnel dryer was found to be 11.40 % at the center of solar tunnel dryer followed by north side (12.19 %) and south side (12.27 %). The increased relative humidity at south side could be attributed to incoming fresh air through air inlets provided at south side of solar tunnel dryer.

Ojike. O et al [14] samples of pawpaw fruit were dried in the open-air and with solar dryers. Vitamin A, B1, B2, C and E were analysed to determine their concentrations before and after drying. In all cases there were significant changes in the concentration of vitamins after drying. The changes were much in open-air drying than in solar dryers used. Thus, the use of solar dryers for drying of pawpaw is highly recommended. Among the solar dryers used Latitudinal box dryer gave the best result in terms of vitamin retention.

6. CONCLUSION

This review paper discussed various types of drying methodologies of present and past. We have discussed in detail about natural convection method of drying which is most suited for agricultural product and eatables to get quantity with expected quality with affordable cost. This method is better than open yard sun drying method in all aspects.

REFERENCES

[1] Ayyappan and Mayilsamy, 'Experimental investigation on a solar tunnel drier for copra drying' Journal of Scientific & Industrial Research Vol.69, pp 635 – 638, 2010.

[2] Emily F. Shanahan et al, 'Evaluation of Pathogen Removal in a Solar Sludge Drying Facility Using Microbial Indicators' International Journal of Environmental Research and Public Health,7,565-582, 2010.

[3] Hitesh N Panchal & Dr. P. K. Shah, 'Effect of Varying Glass cover thickness on Performance of Solar still: in a Winter Climate Conditions' International Journal of Renewable Energy Research, Vol.1, No.4, pp.212-223, 2011.

[4] Manjula et al, 'Drying Characteristics of Byadagi Chilli (Capsicum annuum Linn.) Using Solar Tunnel Dryer' Journal of Agriculture and Food Technology, 1(4) 38-42, 2011.

[5] Joy C.M. and K.P. Jose, 'Drying of Black Pepper (Piper nigrum L.) Using Solar Tunnel Dryer' Pertanika Journal of Tropical Agricultural Science, 25(1) 39 – 45, 2002.

[6] Oparaku, N.F 'Comparative Study of Sun and Solar Cabinet Fish Dryer of Three Freshwater Fish' Continental journal of Fisheries and Aquatic Science, Vol.4, pp8 - 16, 2010.

[7] A.S.M.Mohsin et al, 'Prospect & Future of Solar Dryer: Perspective Bangladesh' IACSIT International Journal of Engineering and Technology, Vol.3, No.2, 2011.

[8] G. M. Kituu, et al 'A Simulation Model for Solar Energy Harnessing by the Tunnel Section of a Solar Tunnel Dryer'

Agricultural Engineering International: CIGR journal. Vol.12 (1), p91, 2010.

[9] S. Janjai et al, 'Experimental and simulated performance of a PV-ventilated solar greenhouse dryer for drying of peeled longan and banana' Journal of Science Direct, Solar Energy 83 (2009) 1550–1565.

[10] A. A. Zomorodian and M. Dadashzadeh, 'Indirect and Mixed Mode Solar Drying Mathematical Models for Sultana Grape', Journal of Agricultural Science and Technology' Vol. 11, 391-400, 2009.

[11] Ahmed Abed Gatea, 'Performance evaluation of a mixed-mode solar dryer for evaporating moisture in beans' Journal of Agricultural Biotechnology and Sustainable Development, Vol. 3(4), pp. 65-71, 2011.

[12] B. K Bala et al, 'Solar drying of mushroom using solar tunnel dryer' International Solar Food Processing Conference 2009.

[13] Mohod A.G et al, 'Solar Tunnel Dryer as an Income Gereration Unit for Fisherman' BIOINFO Renewable & Sustainable Energy, Vol 1(1), pp-01-04, 2011.

[14] Ojike. O et al 'The influence of different solar drying systems on the vitamin content of Pawpaw (*Carica papaya*)', Australian Journal of Agricultural Engineering, Vol. 2(1), 8-11, 2011.

CHAPTER 16: DRYING – GRAIN DRYING, TYPES OF DRYING, TYPES OF DRYERS, IMPORTANCE OF DRYING

- Permits long time storage of grain without deterioration
- Permits continuous supply of product thro' out the year
- Permits early harvest which reduces field damage and shattering loss
- Permits the farmers to have better quality product
- Makes products available during off season

Drying theory

- Convection process in which moisture from a product is removed
- The water content of agricultural product is given in terms of moisture content
- They gain or loose moisture as per the atmospheric conditions
- Moisture migration into or from a product is dependent on the difference of vapour pressure between atmosphere and product
- If the vapour pressure of grain is greater than atmospheric vapour pressure, transfer of moisture from grain to atmosphere takes place
- If the atmospheric vapour pressure is greater than grain vapour pressure, grain absorbs moisture from atmosphere

Drying rate periods

Divided into 3 periods

- Constant rate period
- First Falling rate period
- Second falling rate period

Constant rate period

- Moisture migration rate from inside of product to its surface is equal to the rate of evaporation of water from surface
- This period continues till critical moisture content is reached
- Critical moisture content: Moisture content of a product where constant rate drying ceases and falling rate starts
- This period is very short for agricultural products
- Drying of sand and washed seeds takes place in constant rate period

Falling rate period

- Most of the agricultural products are dried in falling rate drying period
- Movement and diffusion of moisture in interior of grains controls the entire drying process

Controlled by

- Migration of moisture from interior of grains to upper surface due to water vapour diffusion
- Removal of moisture from the surface
- Divided into two periods
- First falling rate period
- Second falling rate period

First falling rate

- Unsaturated surface drying
- Drying rate decreases because of the decrease in wet surface area
- Fraction of wet surface decreases to zero, where first falling rate ends

Second falling rate

- Sub surface evaporation takes place & it continues until the equilibrium moisture content is reached

Mechanism of drying process

- Movement of moisture takes place due to
- Capillary flow – Liquid movement due to surface forces
- Liquid diffusion – Liquid movement due to difference in moisture concentration
- Surface diffusion - Liquid movement due to moisture diffusion of the pore spaces
- Vapour diffusion – vapour movement due to moisture concentration difference
- Thermal diffusion - vapour movement due to temperature difference
- Hydro dynamic flow – water and vapour movement due to total pressure difference

Thin layer drying

- Process in which all grains are fully exposed to the drying air under constant drying conditions i.e. at constant air temp. & humidity.
- Up to 20 cm thickness of grain bed is taken as thin layer
- All commercial dryers are designed based on thin layer drying principles
- Represented by Newton's law by replacing moisture content in place of temperature

$M-M_e/M_o-M_e = e^{-K\theta}$

M – Moisture content at any time θ, % db

Me- EMC, %db

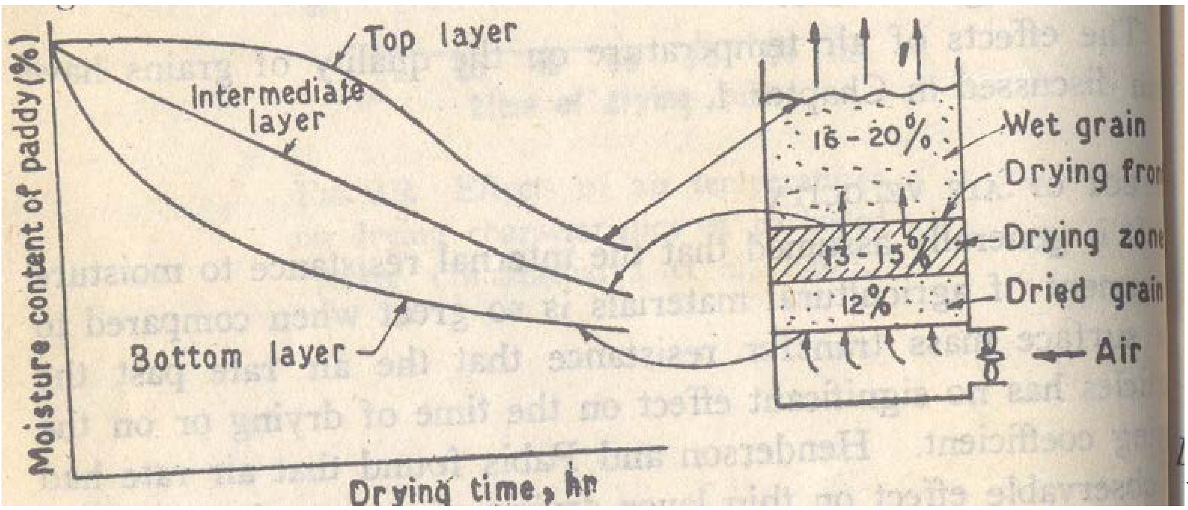
Mo – Initial moisture content, %db

K – drying constant

θ - time, hour

Deep bed drying

- All grains are not fully exposed to the same condition of drying air
- Condition of drying air changes with time and depth of grain bed
- Rate of airflow per unit mass of grain is small
- Drying of grain in deep bin can be taken as sum of several thin layers
- Humidity & temperature of air entering & leaving each layer vary with time
- Volume of drying zone varies with temp & humidity of entering air, moisture content of grain & velocity of air



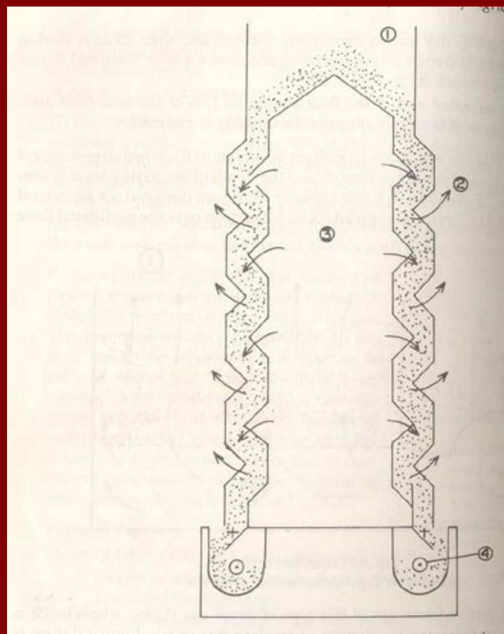
Deep bed drying characteristics at different depths

Continuous flow dryer

- Columnar type dryer in which wet grains flow from top to the bottom of the dryer
- Two types
- Mixing
- Non-mixing

Mixing

- Grains are diverted in the dryer by providing baffles
- Use low air flow rates of 50-95 m3/min/tonne
- Zig-zag columns enclosed by screens are used to achieve mixing
- High drying air temperature of 65°C is used

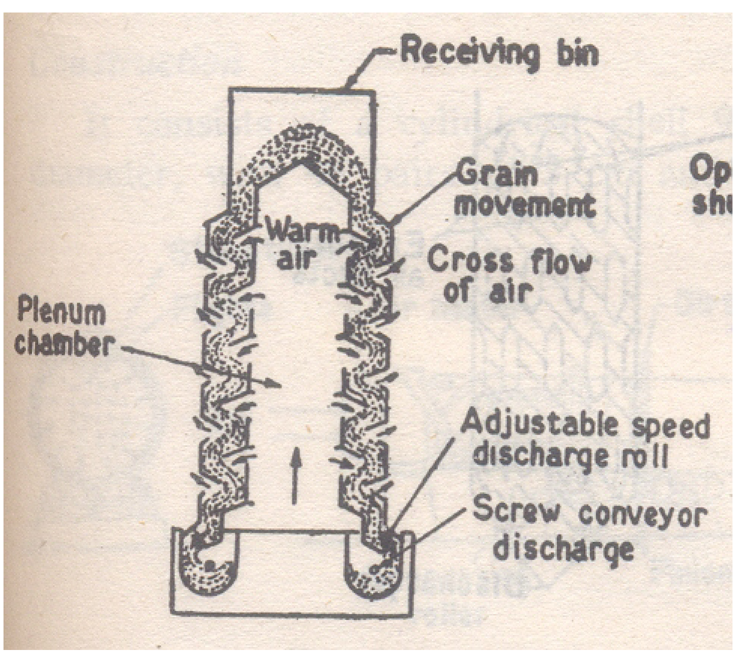


1. Feed hopper
2. Exit air
3. Plenum chamber
4. Dry material outlet

Continuous flow dryer (Mixing type)

Baffle dryer

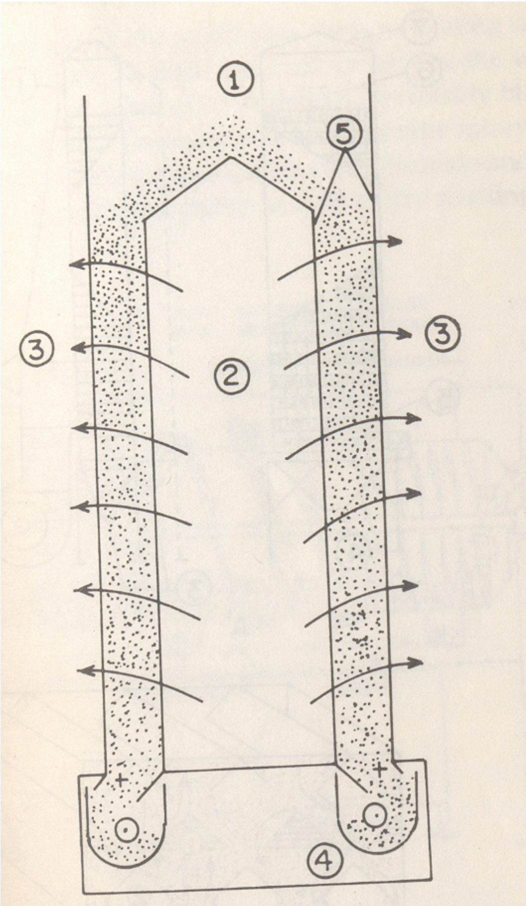
- Continuous flow mixing type dryer
- Consists of receiving bin, drying chamber fitted with baffles, plenum fitted with hot air inlet
- Baffles are fitted to divert the flow & also for mixing
- Grain fed at the top & move downward in a zig-zag path where it encounters a cross flow of hot air
- Bucket elevator is used to recirculate the grain till the grain is dried to desired moisture level
- Uniformly dried product is obtained



Mixing type baffle dryer

Non-mixing

- Grains flow in a straight path
- Baffles are not provided and drying takes place between two parallel screens
- High airflow rates can be used
- Drying air temp. of 54°C is used



1. Feed hopper
2. Plenum chamber
3. Exit air
4. Dry grain outlet
5. Screened grain column

Continuous flow dryer (Non-mixing)

Recirculatory Batch dryer

- Continuous flow non mixing type
- Consists of 2 concentric circular cylinders, set 15-20 cm apart

Bucket elevator is used to feed & recirculated the grain

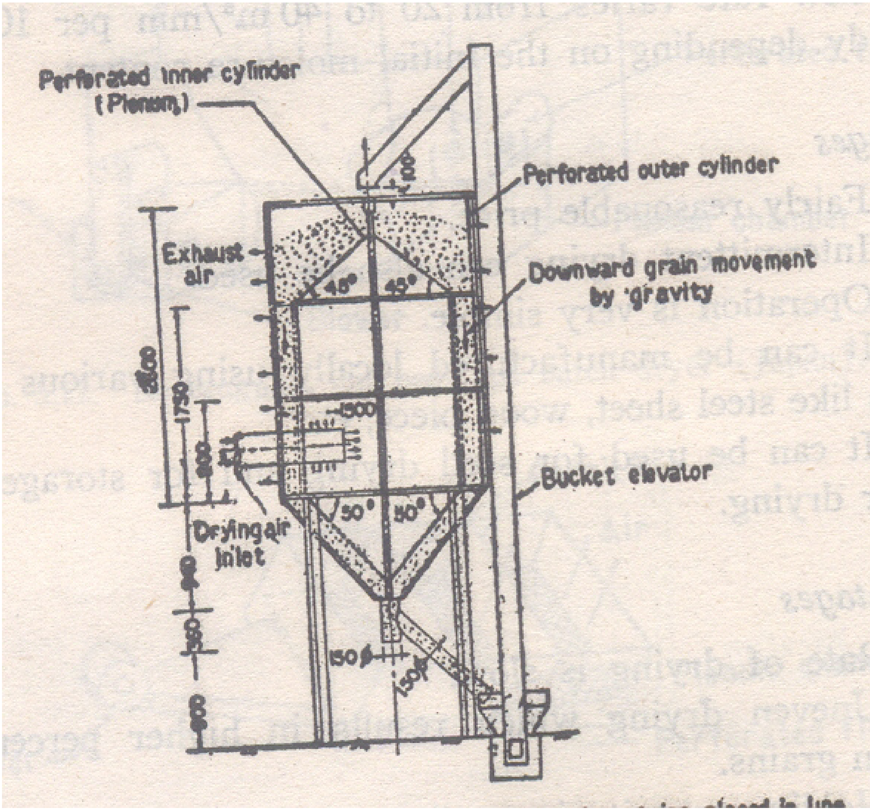
Centrifugal blower blows the hot air into the inner cylinder, acts as a plenum

Grain is fed at the top of the inside cylinder; comes in contact with a cross flow of hot air

The exhaust air comes out through perforations of the outer cylinder

Grain is recirculated till it is dried to desired moisture content

Drying is not uniform as compared to mixing type

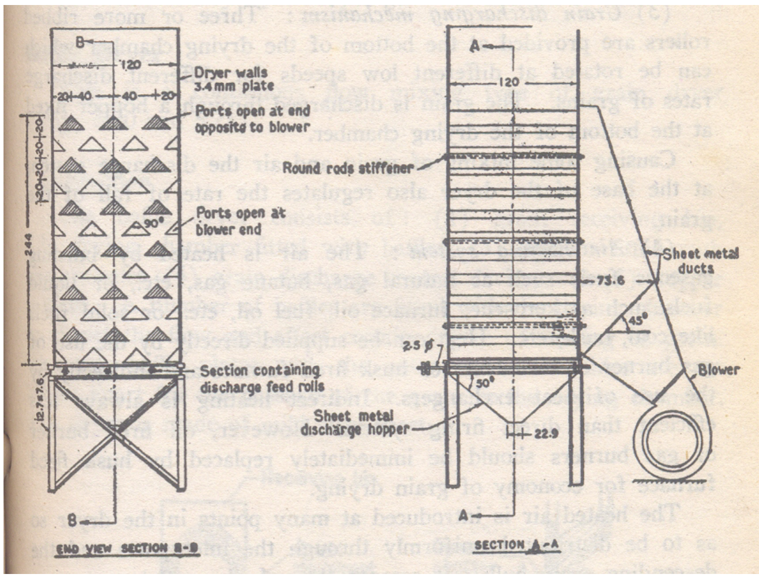


Recirculating batch dryer

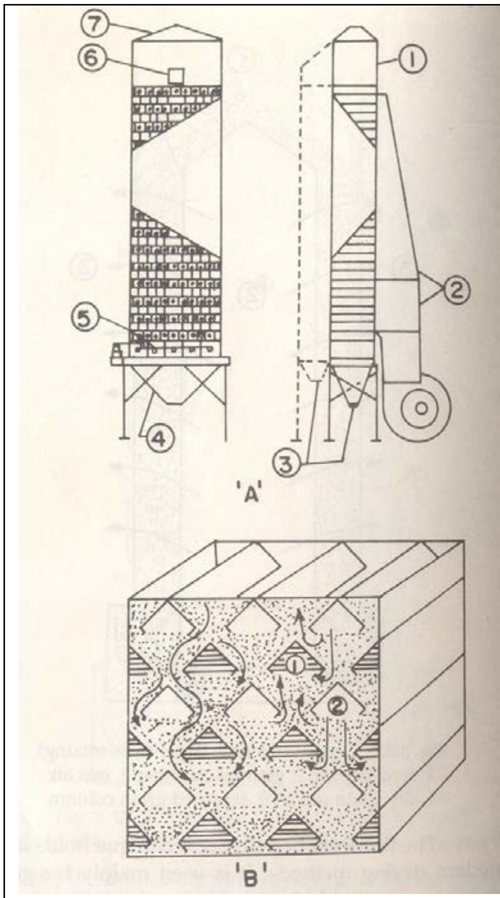
LSU dryer

- Developed at Louisiana state university (LSU)
- Continuous mixing type dryer
- Developed specifically for rice to ensure gentle treatment, good mixing & good air to grain contact
- Consists of rectangular chamber, holding bin, blower with duct, grain discharging mechanism and air heating system
- Layers of inverted V shaped channels are installed in the drying chamber; heated air is introduced through these channels at many points
- Alternate layers are air inlet & outlet channels; arranged one below the other in an offset pattern
- Inlet port consists of few full size ports & two half size ports; all ports are of same size arranged in equal spacing
- Ribbed rollers are provided at the bottom of drying chamber for the discharge of grain
- Capacity varies from 2-12 tonnes

- Recommended air flow rate is 60-70 m3/min/tonne
- Air temp. are 60 &85°C for raw & parboiled paddy
- Uniformly dried product can be obtained
- Can be used for different types of grain
- High capital investment



LSU Dryer

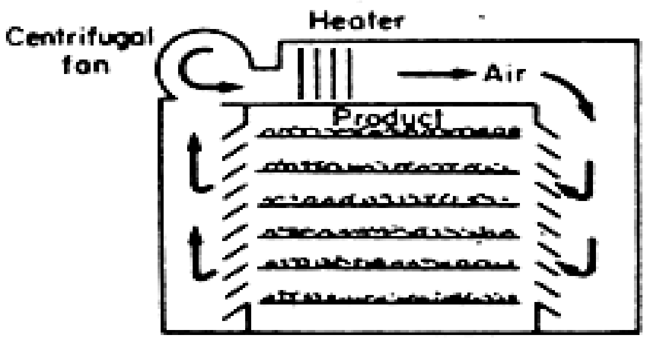


1. Garner
2. Duct
3. Dry material outlet
4. Hopper
5. Continuous flow
6. Door
7. Roof

LSU Dryer

Tray driers

- In tray dryers, the food is spread out, generally quite thinly, on trays in which the drying takes place.
- Heating may be by an air current sweeping across the trays, or heated shelves on which the trays lie, or by radiation from heated surfaces.
- Most tray dryers are heated by air, which also removes the moist vapours.

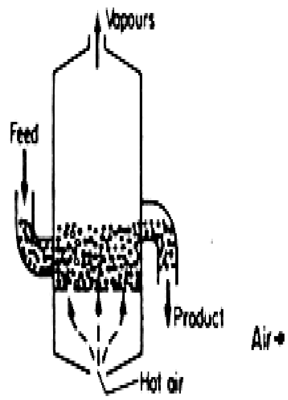


TRAY DRYER

Fluidized Bed Dryers

In a fluidized bed dryer, the food material is maintained suspended against gravity in an upward-flowing air stream.

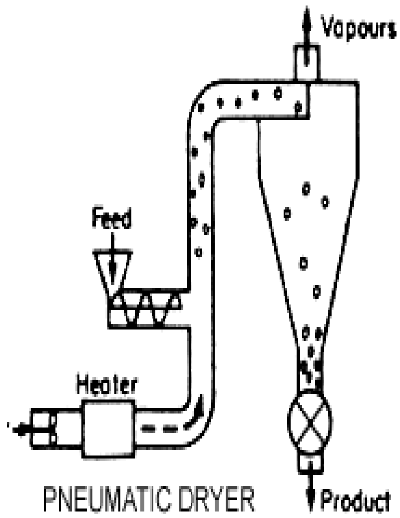
Heat is transferred from the air to the food material, mostly by convection



FLUIDISED BED DRYER

Pneumatic Dryers

- In a pneumatic dryer, the solid food particles are conveyed rapidly in an air stream, the velocity and turbulence of the stream maintaining the particles in suspension.
- Heated air accomplishes the drying and often some form of classifying device is included in the equipment.
- In the classifier, the dried material is separated, the dry material passes out as product and the moist remainder is recirculated for further drying



Rotary Dryers

- The foodstuff is contained in a horizontal inclined cylinder through which it travels, being heated either by air flow through the cylinder, or by conduction of heat from the cylinder walls.
- In some cases, the cylinder rotates and in others the cylinder is stationary and a paddle or screw rotates within the cylinder conveying the material through.