

**24AG301- APPLIED THERMODYNAMICS AND THERMAL  
SYSTEMS IN AGRICULTURAL ENGINEERING**

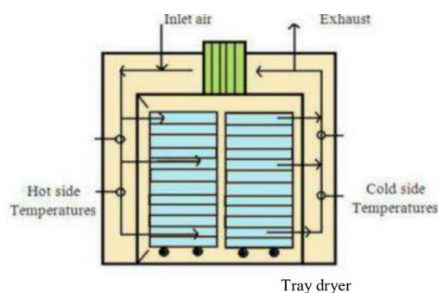
**UNIT 5 CROP DRYING AND HEATING SYSTEMS**

HANDLED BY  
MS SWETHA S



## Tray Dryer

Schematic of a typical batch dryer is shown in figure. Tray dryers usually operate in batch mode, use racks to hold product and circulate air over the material. It consists of a rectangular chamber of sheet metal containing trucks that support racks. Each rack carries a number of trays that are loaded with the material to be dried. Hot air flows through the tunnel over the racks. Sometimes fans are used to on the tunnel wall to blow hot air across the trays. Even baffles are used to distribute the air uniformly over the stack of trays. Some moist air is continuously vented through exhaust duct; makeup fresh air enters through the inlet. The racks with the dried product are taken to a tray-dumping station.



## Rotary Dryer

This is continuous dryer as it produces the final dried product continuously.

- Horizontal rotary dryers of various designs countries for the drying of parboiled paddy have been developed by different
- Some of them are fitted with external steam well.
- As parboiled paddy can stand high temperature without significant increase of cracks in grains, these dryers can be employed for rapid drying of parboiled paddy using temperatures as high as 100 to 110°C.

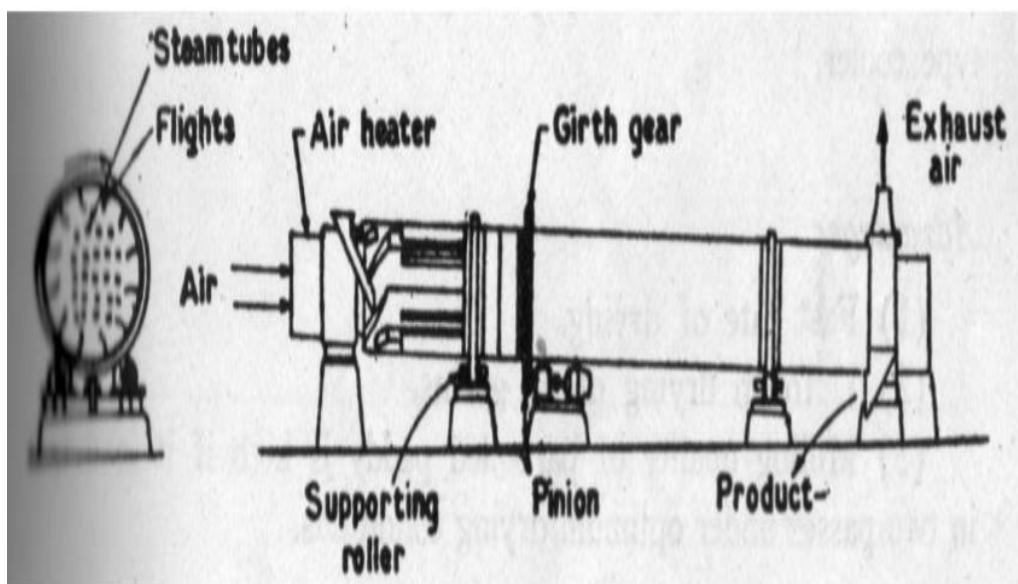
### Construction

- It consists of a cylindrical shell 9.15 m long and 1.22 m in diameter, with 48 pairs of 5 cm and 3.75 cm size steam pipes in two concentric rows inside the shell in combination with common steam inlet and condensate outlet fittings.
- The shell is equipped with six longitudinal flights of 9.15 m long and 15.24 cm wide for lifting and forward movement of the parboiled paddy towards the discharge end while it is being dried.
- The dryer is equipped with an air blower and a small steam tube heat exchanger for supplying heated air at the entrance of the feed end breeching box.
- The cylindrical shell of the dryer is rotated at 2 to 6 rpm by a motor through speed

### Operation

- The soaked and steamed paddy is fed to the dryer by the screw feeder.

- Heated air at about 80°C is blown (from the feed end) through the dryer in the same direction as the paddy moves and exhausted through the exhaust pipe. Heated air acts here mainly as a carrier of moisture from the dryer.
- While traveling from the feed end to the discharge end of the dryer the parboiled paddy comes in contact with the steam heated pipes for a very short time in each rotation and is gradually dried to about 16% moisture content in a single pass.
- Therefore, drying is accomplished mainly by the conduction of heat from the steam pipe to the grain.
- The traveling time of the grain in the dryer is adjusted to 30 to 45 min by adjusting inclination and rpm of the dryer.
- The hot paddy discharged from the dryer is then aerated by passing it through a cup and cone type cooler.



#### **Advantages:**

1. Fast rate of drying
2. Uniform drying of all grains
3. Milling quality of parboiled paddy is high if it is dried in two passes under optimum drying conditions.

#### **Disadvantages:**

1. Complicated design
2. Needs careful attention
3. Higher capital investment
4. Higher power requirement

5. Operating cost may be high due to higher consumption of electricity and steam.
6. The dryer being horizontal larger floor space is required.
7. Generally only 30 per cent of the dryer volume is utilized.
8. It cannot be used for all types of freshly harvested grains

### **Recirculatory Batch Dryer (PHTC type)**

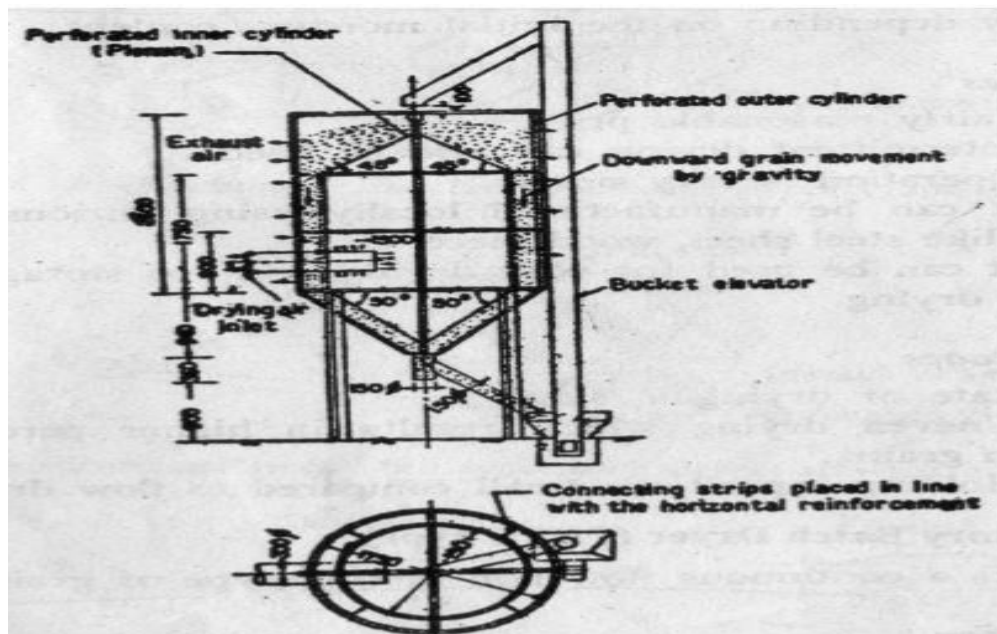
This is a continuous flow non mixing type of grain dryer.

#### **Construction**

The dryer consists of two concentric circular cylinders made of perforated (2 mm dia) mild steel sheet of 20 gauge.

The two cylinders are set 15 to 20cm apart. These two cylinders are supported on four channel sections. The whole frame can be supported by a suitable foundation or may be bolted to a frame made of channel section.

A bucket elevator of suitable capacity is used to feed and recirculate the grain into the dryer.



#### **Operation**

- The grain is fed to the top of the inside cylinder. While descending through the annular space from the feed end to the discharge end by gravity, the grain comes in contact with a cross flow of hot air.
- The exhaust air comes out through the perforations of the outer cylinder and the grain is discharged through the outlet of the hopper.
- The feed rate of grain is controlled by closing or opening the gate provided with the outer pipe of the discharge hopper.
- The grain is recirculated till it is dried to the desired moisture level.

Advantages:

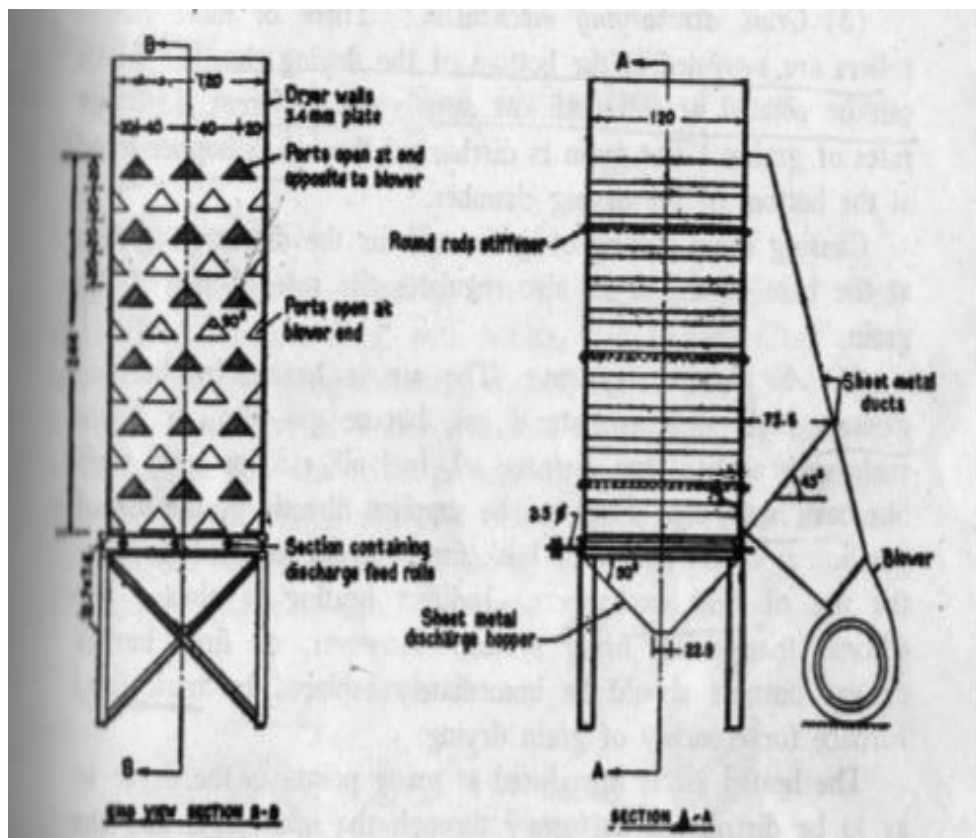
1. Price is reasonable
2. Simplest design amongst all flow type dryers
3. Easy to operate
4. It can be used on the farm and rice mill as well
5. Operating cost is low with husk fired furnace.

Disadvantages:

1. Drying is not so uniform as compared to mixing type
2. Perforations of the cylinders may be clogged with the parboiled paddy after using it for a long time.

### Louisiana State University Dryer

This is a continuous flow-mixing type of grain dryer which is popular in India and the U.S.A.



### Construction

It consists of

- 1) a rectangular drying chamber fitted with air ports and the holding bin,
- 2) an air blower with duct,
- 3) grain discharging mechanism with a hopper bottom
- 4) an air heating system.

#### 1)Rectangular bin:

Usually the following top square sections of the bin are used for the design of LSU dryer.

- i) 1.2m x 1.2m,
- ii) 1.5m x 1.5m,
- iii) 1.8m x 1.8m and
- iv) 2.1m x 2.1m

The rectangular bin can be divided into two sections, namely top holding bin and bottom drying chamber

## **2)Air distribution system:**

- Layers of inverted V-shaped channels (called inverted V ports) are installed in the drying chamber.
- Heated air is introduced at many points through the descending grain bulk
- One end of each air channel has an opening and the other end is sealed. Alternate layers are air inlet and air outlet channels.
- All these ports of same size are arranged in equal spacing between them. The number of ports containing a dryer varies widely depending on the size of the dryer.

Layers of inverted V-shaped channels (called inverted Vports) are installed in the drying chamber. Heated air is introduced at many points through the descending grain bulk through these channels. One end of each air channel has an opening and the other end is sealed. Alternate layers are air inlet and air outlet channels. In the inlet layers, the channel openings face the air inlet plenum chamber but they are sealed at the opposite wall, where as in the outlet layers, the channel openings face the exhaust but are sealed other side. The inlet and outlet ports are arranged one below the other in an offset pattern. Thus air is forced through the descending grain while moving from the feed end to the discharge end. The inlet ports consists of a few full size ports and two half size ports at two sides. All these ports of same size are arranged in equal spacing between them. The number of ports containing a dryer varies widely depending on the size of the dryer. Each layer is offset so that the top of the inverted V ports helps in splitting the stream of grain and flowing the grains between these ports taking a zigzag path. In most models, the heated air is supplied by a blower

## **3)Grain discharging mechanism:**

- Three or more ribbed rollers are provided at the bottom of the drying chamber which can be rotated at different low speeds for different discharge rates of grains.
- The grain is discharged through a hopper fixed at the bottom of the drying chamber. Causing some mixing of grain and air the discharge system at the base of the dryer also regulates the rate of fall of the grain.

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## **4)Air heating system:**

- The air is heated by burning gaseous fuels such as natural gas, butane gas, etc, or liquid fuels such as kerosene, furnace oil, fuel oil etc, or solid fuels like coal, husk, etc.
- Heat can be supplied directly by the use of gas burner or oil burner or husk fired furnace and indirectly by the use of heat exchangers.

- Indirect heating is always less efficient than direct firing system. However, oil fired burner or gas burners should be immediately replaced by husk fired furnace for economy of grain drying.

- The heated air is introduced at many points in the drier so as to be distributed uniformly through the inlet ports and the descending grain bulk. It escapes through the outlet ports.

- This type of dryer is sometimes equipped with a special fan to blow ambient air from the bottom cooling section in which the dried or partially dried warm grain comes in contact with the ambient air.

- In general, the capacity of the dryer varies from 2 to 12 tonnes of grain, but sometimes dryers of higher capacities are also installed.

- Recommended air flow rate is 60-70 m<sup>3</sup>/min/tonne of parboiled paddy and optimum air temperatures are 600C and 850C for raw and parboiled paddy respectively.

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### **Advantages:**

- 1.Uniformly dried product can be obtained if the dryer is designed properly
- 2.The dryer can be used for different types of grains.

### **Disadvantages:**

1. High capital investment
2. Cost of drying is very high if oil is used as fuel.

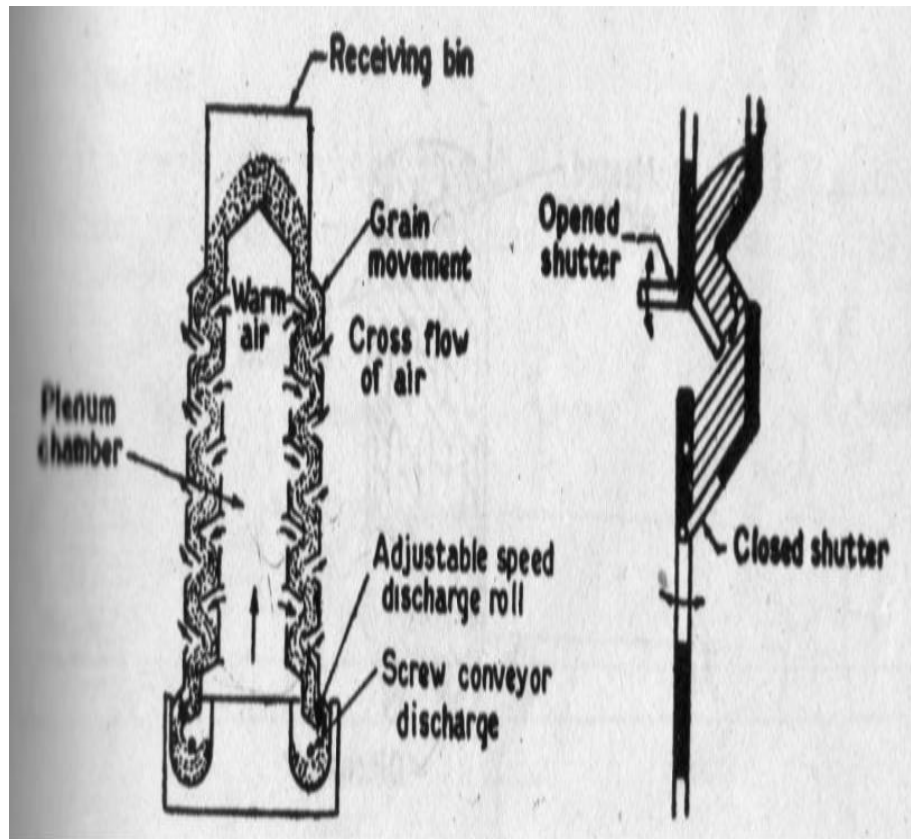
### **Baffle Dryer**

This is a continuous flow mixing type of grain dryer.

### **Construction**

- The baffle dryer consists of: 1) grain receiving bin, 2) drying chamber fitted with baffles, 3) plenum fitted with hot air inlet, 4) grain discharge control device and 5) hopper bottom.

- A number of baffles are fitted with the drying chamber to divert the flow and effect certain degree of mixing of grain.
- The two baffle plates with the outer and inner sides are set 20cm apart for the passage of the grain in the drying chamber. The dryer is made of mild steel sheet.



#### Operation:

- Grain is fed at the top of the receiving bin and allowed to move downward in a zigzag path through the drying chamber where it encounters a cross flow of hot air.
- On account of zigzag movement, a certain degree of mixing of grain takes place.
- The particularly dried grain discharged from the hopper bottom is recirculated by a bucket elevator until it is dried to the desired moisture level.
- Some of the dryers are fitted with a large overhead bin at the top which acts as an overhead tempering bin.

#### Advantages:

1. Uniformly dried product is obtained
- Disadvantages:
1. Ratio of the volume of plenum to the total volume of the dryer is relatively high.
  2. Grains on the baffle plates move slowly than that of other sections.

#### Rotary Dryer

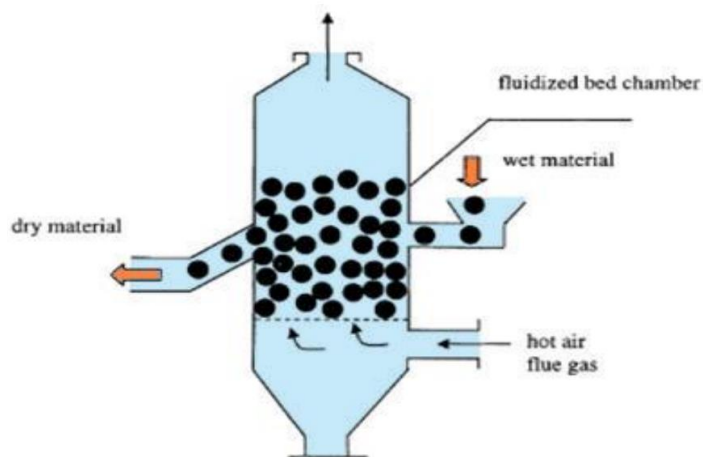
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- As parboiled paddy can stand high temperature without significant increase of cracks in grains, these dryers can be employed for rapid drying of parboiled paddy using temperatures as high as 100 to 110°C.

### FLUIDIZED BED DRYER

The airflow through the bed of product is kept at a level such that the product is lifted and is in the suspended form during drying.

- In continuous types, wet feed is admitted to the top of the bed and dried product is taken out from the bottom.
- The tray vibrates to move the food under gravity from one tray to next.
- In batch type, the wet feed is kept on the perforated bed and is exposed to hot air in fluidized chamber until it gets dried.
- A distributor is present to distribute air at uniform velocity.
- Plenum chamber is present for uniform distribution of hot air.



- If fine particles are present, then cyclones are needed for fine recovery.
- Drying rate is good.
- Uniform mixing is achieved.
- High thermal efficiency and drying rates.
- The food products should not clump or stick to each other.
- The food product must withstand the agitation without product degradation.
- Application: • Used for granulated powder. • Eg: pea, starch powder, diced vegetables

Important factors affecting the rate of drying are

1. Initial moisture content of the raw material
2. Composition of raw material
3. Initial load of the food kept in drier