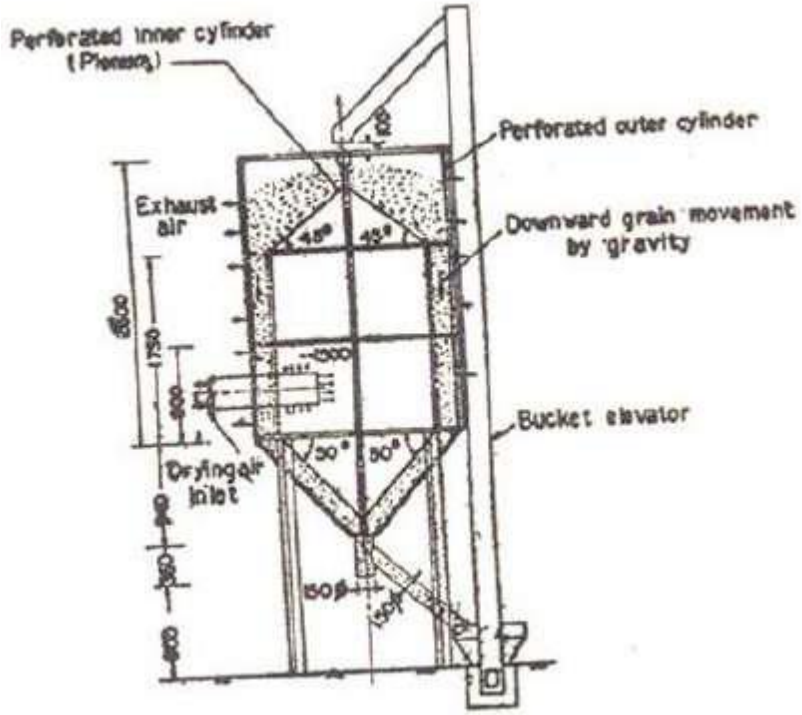
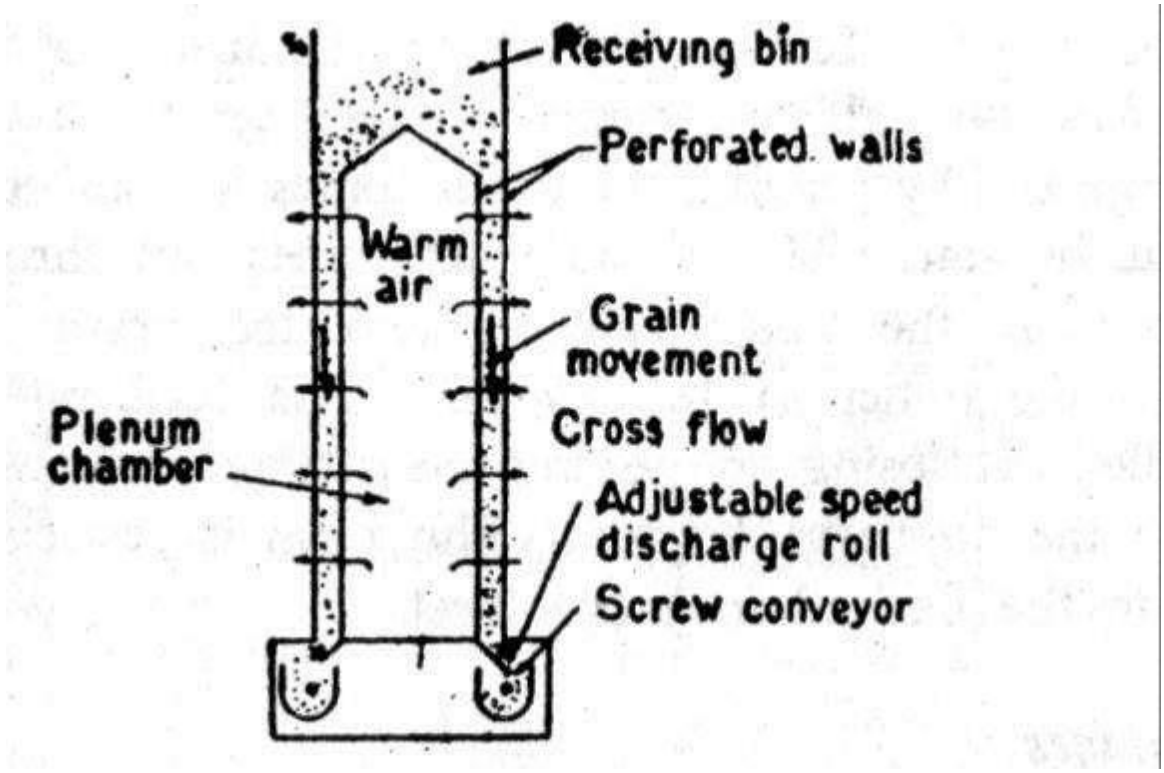
Types of dryers

Recirculatory Batch Dryer (PHTC type)

This is a continuous flow non mixing type of grain dryer.The dryer consists of two concentric circular cylinders made of perforated (2mm 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. A centrifugal blower blows the hot air into the inner cylinder which acts as a plenum. The hot air from the plenum passes through the grain moving downward by gravity and comes out of the outer perforated cylinder. A torch burner is employed to supply the necessary heat with kerosene oil as fuel. The designs of PHTC dryer for ½, 1 and 2 tonnes holding capacity are available. The PHTC dryer of 2 tonnes holding capacity developed at PHTC, IIT, Kharagpur, India is shown in fig.



Recirculatory batch dryer



Continuous flow type non mixing type dryer

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.

13.2 Louisiana State University Dryer

This is a continuous flow-mixing type of grain dryer which is popular in India andtheU.S.A.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, and 4) an air eating system.

1) **Rectangular bin**:

Usually the following top square sections of the bin are used for thedesign 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.

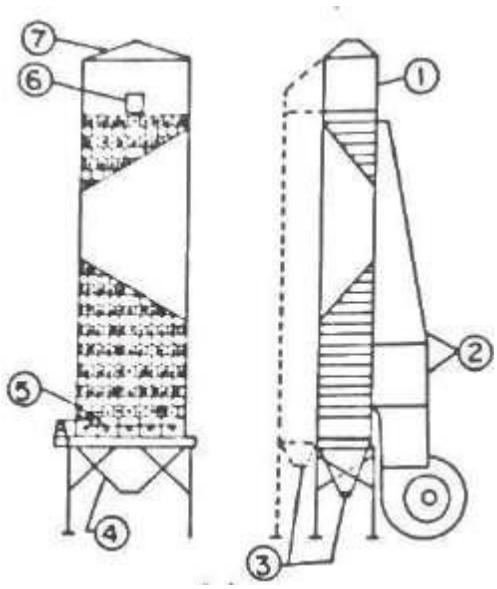
2) **Air distribution system**: Layers of inverted V-shaped channels (called inverted Vports) are installed in the drying chamber. Heated air is introduced at many points through the descending grain bulk through these channels. One end of each air channel has an opening and the other end is sealed. 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.

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 graincomes in contact with the ambient air. In general, the capacity of the dryer varies from 2 to 12tonnes of grain, but sometimes dryers of higher capacities are also installed. Accordingly power requirement varies widely. Recommended air flow rate is 60-70 m3/min/tonne of parboiled paddy and optimum air temperatures are 600C and 850C for raw and parboiled paddy respectively. A series of dryers can also be installed.

Advantages & Disadvantages

- Uniformly dried product can be obtained if the dryer is designed properly.
- The dryer can be used for different types of grains.
- High capital investment
- Cost of drying is very high if oil is used as fuel.

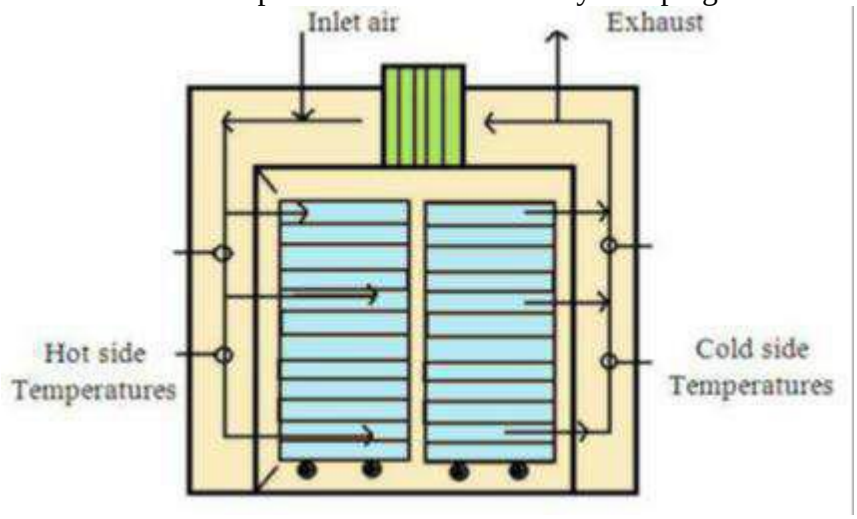


LSU dryer

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

Tray Dryer

Schematic of a typical batch dryer is shown in fig. 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



Tray dryer

These types of dryers are useful when the production rate is small. They are used to dry

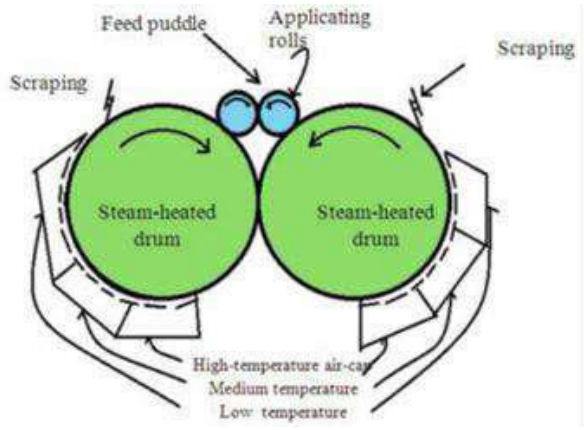
wide range of materials, but have high labor requirement for loading and unloading the materials, and are expensive to operate. They find most frequent application for drying valuable products. Drying operation in case of such dryers is slow and requires several hours to complete drying of one batch. With indirect heating often the dryers may be operated under vaccum. The trays may rest on hollow plates supplied with steam or hot water or may themselves contain spaces for a heating fluid. Vapour from the solid may be removed by an ejector or vacuum pump.

Drum Dryer

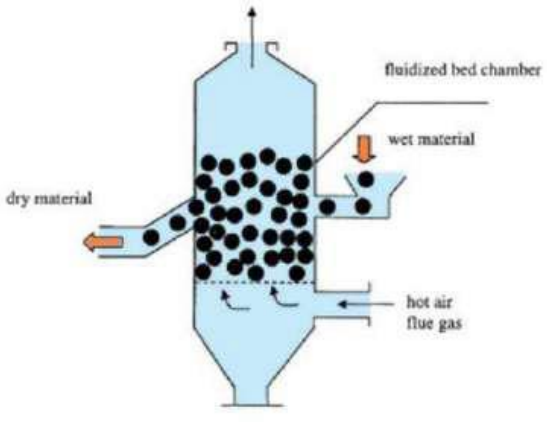
In drum dryers a liquid containing dissolved solids or slurry carrying suspended solids forms a thin layer on the outside surface of a large rotating drum. For a single drum unit thickness of the film can be controlled by an adjustable scraping blade. In case of a double drum unit thickness can be controlled by the gap between the drums. A gas, normally air may be blown over the surface for rapid removal of moisture. The rotation of the drum adjusted so that all of the liquid is fully vaporized and a dried deposit can be scrapped off with the help of flexible or adjustable knife. This type of dryer mainly handles the materials that are too thick for a spray dryer and too thin for a rotary dryer. The solid collects on an apron in front of the knife and rolls to a container or to a screw conveyor. The operation of the drum drier is continuous. The drum is rotated continuously by a gear driven by a pinion that receives its motion through a belt, a chain, or a reduction gear from. The speed of the drum may be regulated by a variable-speed drive to adopt the speed to any slight variation in the feed quality. The speed of the drum regulated depending upon the nature of materials (i.e wet or dry), if the product material is wet/dry quite a distance before the knife is reached, the speed should be decreased/increased. The design of the components is similar to that of drum filter. The knife may be held just against the surface. It may be brought closer by turning the adjusting wheels. The knife supports may be turned through part of a circle so that the angle of the blade of the knife relative to the drum surface may be selected for the greatest shearing effect. In recent years, double drum dryers have replaced single drum dryer in several applications due to their more efficient operation, wide range of products and high production rates.

Fluidized Bed Dryer

Fluidized bed dryer consist of a steel shell of cylindrical or rectangular cross section. A grid is provided in the column over which the wet material is rests. In this type of dryer, the drying gas is passed through the bed of solids at a velocity sufficient to keep the bed in a fluidized state. Mixing and heat transfer are very rapid in this type of dryers. The dryer can be operated in batch or continuous mode. Fluidized bed dryer are suitable for granular and crystalline materials. If fine particles are present, either from the feed or from particle reakage in the fluidized bed, there may be considerable solid carryover with the exit gas and bag filters are needed for fines recovery. The main advantage of this type of dryer are: rapid and uniform heat transfer, short drying time, good control of the drying conditions. In case of rectangular fluid-bed dryers separate fluidized compartments are provided through which the solids move in sequence from inlet to outlet. These are known as *plug flow dryers;* residence time is almost the same for all particles in the compartments. But the drying conditions can be changed from one compartment to another, and often the last compartment is fluidized with cold gas to cool the solid before discharge.



Drum dryer



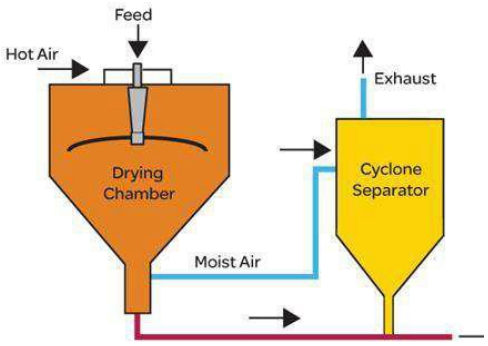
Fluidized bed dryer

Spray Dryers

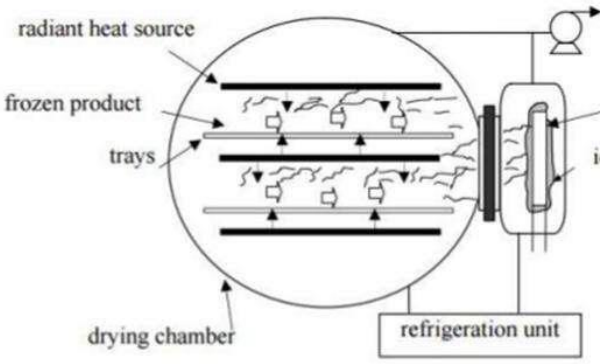
In a spray dryer, foods are transformed from slurry into a dry powder. A fine dispersion of pre-concentrated food is first _atomized‘ to form droplets (10-200 μm diameter) and sprayed into a current of heated air at 150-300°C in a large drying chamber The spray-drying operation is easily divided into three distinct processes; atomization, drying through the contact between the droplets and the heated air, and collection of the product by separating it from the drying air. While liquid food droplets are moving with the heated air, the water evaporates and is carried away by the air. Much of the drying occurs during a constant-rate period and is limited by mass transfer at the droplet surface. After reaching the critical moisture content, the dry food particle structure influences the falling-rate drying period. During this portion of the process, moisture diffusion within the particle becomes the rate-limiting parameter. After the dry food particles leave the drying chamber, the product is separated from air in a cyclone separator. The dried product is then placed in a sealed container at moisture contents that are usually below 5%. Product quality is considered excellent due to the protection of product solids by evaporative cooling in the spray dryer. The small particle size of dried solids promotes easy reconstitution when mixed with water.

Freeze Dryers

Freeze-drying is accomplished by reducing the product temperature so that most of the product moisture is in a solid state, and by decreasing the pressure around the product, sublimation of ice can be achieved. When product quality is an important factor for consumer acceptance, freeze-drying provides an alternative approach for moisture removal.



Spray dryer



Freeze dryer

Material handling Equipment

Material handling includes a number of operations that can be executed either by hand (manual) or by mechanical means or devices to convey material and to reduce the human drudgery. The most common types of mechanical devices for grain handling are;

1. Belt conveyor
2. Bucket elevator
3. Screw conveyor
4. Chain Conveyor
5. Pneumatic conveyor

Selection of material Handling machines and Conveyors

The selection of proper conveying system is important for ease in operation and getting desired capacity for a particular product. Principles based on which the material handling equipment is selected:

- Based on the characteristics of the products being conveyed
- Working and climatic conditions.
- The capacity of conveying
- In a conveying system possibility of use of gravity.
- The capacity of handling / conveying equipment should match with the capacity of processing unit or units.
- Spillage of conveyed products should be avoided.
- Pollution of the environment due to noise or dust by the conveying system should also be avoided.

Belt conveyors

A belt conveyor is an endless belt operating between two pulleys with its load supported on idlers. The belt may be flat for transporting bagged material or V-shaped. The belt conveyor consists of a belt, drive mechanism and end pulleys, idlers and loading and discharge devices.

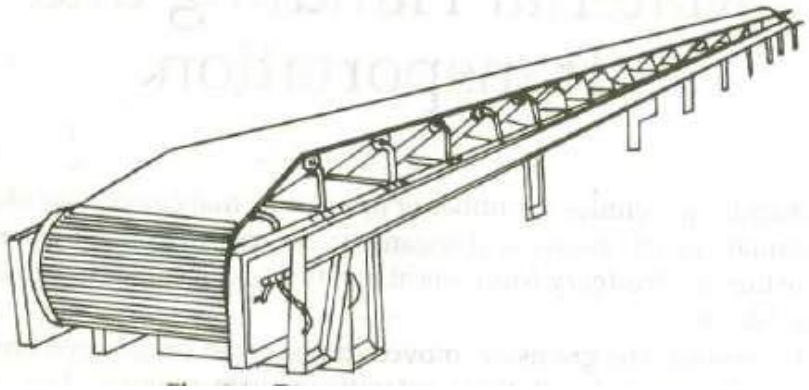


Diagram of belt conveyor

On the belt conveyor baggage/ product lie still on the surface of belt and there is no relative motion between the product and belt. This results in generally no damage to material. Belt can be run at higher speeds, so, large carrying capacities are possible. Horizontally the material can be transported to longer distance. The initial cost of belt conveyor is high for short distances, but for longer distances the initial cost of belt conveying system is low. The first step in the design of a belt conveyor with a specified conveying capacity is to determine the speed and width of the belt. The belt speed should be selected to minimize product spillage or removal of fines due to velocity of the belt. For transportation of grains, the belt speed should not increase 3.5 m/s. Generally, for grain conveying, belt speed of 2.5 to 2.8 m/s

is recommended. The selection of belt width will depend upon the capacity requirement, speed of operation, angle of inclination of belt conveyor, trough angle and depth.

14.3 Bucket Elevator

A bucket elevator consists of buckets attached to a chain or belt that revolves around two pulleys one at top and the other at bottom. The vertical lift of the elevator may range between few metres to more than 50 m. **Capacities of bucket elevators may vary from 2 to 1000 t/hr.** Bucket elevators are broadly classified into two general types, (1) spaced bucket elevators and (2) continuous bucket elevators. The spaced bucket elevators are further classified as,

(1) centrifugal discharge elevators,
(2) positive-discharge elevators,
(3) marine leg elevators and
(4) high-speed elevators.

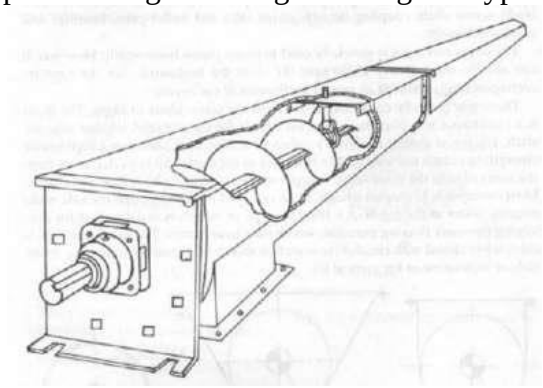
The continuous bucket elevators are classified as

(1) super capacity bucket elevators and
(2) internal-discharge bucket elevators.

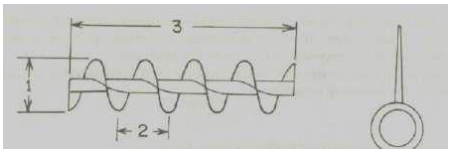
The spaced bucket centrifugal discharge type is most commonly used for elevating the grains. The bucket elevator is a very efficient device for the vertical conveyance of bulk grains. Bucket elevators with belts are employed in food industries for vertical conveyance of grains, derivatives and flours. Bucket elevators are usually mounted at a fixed location, but they can also be mounted in a mobile frame. Bucket elevators have high capacities and it is a fairly cheap means of vertical conveyance.It requires limited horizontal space and the operation of conveying is enclosed in housing, thus it is dust free and fairly quite. The bucket elevator has limited wear problem since the product is enclosed in buckets. The buckets are enclosed in a single housing called leg, or two legs may be used. The return leg may be located at some distance from the elevator leg. The boot can be loaded from the front or back or both.

14.4 Screw Conveyor

The screw conveyor consists of a tubular or U-shaped trough in which a shaft with spiral screw revolves. The screw shaft is supported hanger bearings at ends. The rotation of screw pushes the grain along the trough. A typical screw conveyor is shown in the following Figure



Screw conveyor.



Screw conveyor details

The screw conveyor is used in grain handling facilities, animal feed industries and other installations for conveying of products generally for short distances. Screw conveyor requires relatively high power and is more susceptible to wear than other types of conveyors. The pitch of a standard screw which is the distance from the centre of one thread to the centre of the next thread is equal to its diameter. For example a 10 cm diameter screw has a pitch of 10 cm.

As the screw conveyor's driving mechanism is simpler, and no tensioning device is required, the initial cost of the conveyor is lower than any other conveyor with the same length and capacity. The main parts of a screw conveyor are, screw blade, screw shaft, coupling, trough, cover, inlet and outlet gates, bearings and drive mechanism. The screw conveyor is generally used to move grains horizontally. However, it can also be used at any angle up to 90° from the horizontal, but the capacity correspondingly reduced as per the inclination of conveyance. The screw basically consists of a shaft and the screw blade or flight. The flight is a continuous one piece helix shaped from a flat strip of steel welded onto the shaft. The screw shaft is usually a joint less tube with thick sides and a high tensile strength to reduce the weight. The thickness of the steel strip helix decreases from the inner edge to the outer edge. Troughs of screw conveyor have different shapes. Most common is U shaped trough. In an enlarged or flared trough the side walls become wider at the top (Figure). This type of trough is usually used for conveying non-easy flowing materials which may have lumps. The tubular trough is completely closed with circular cross-section and mostly used for conveying materials at inclination or for vertical lift.

Pneumatic Conveyor

The pneumatic conveyor moves granular materials in a closed duct by a high velocity air stream. Pneumatic conveying is a continuous and flexible transportation method. The material is carried in pipelines either by suction or blowing pressure of air stream. The granular materials because of high air pressure are conveyed in dispersed condition. For dispersion of bulk material, air velocities in the range of 15-30 m/s is necessary. The pneumatic conveying system needs a source of air blowing or suction, means of feeding the product into the conveyor, ducts and a cyclone or receiving hopper for collection of product. There are three basic systems of pneumatic conveying. These are pressure or blowing system, suction or vacuum system, and combined push-pull or suck blow system. In blowing or positive pressure systems, the product is conveyed by using air pressures greater than the atmospheric pressure. The selection of air mover is the most important aspect of the design of a pneumatic conveying system. In design, the two factors, (1) supply air pressure and (2) the volumetric flow rate of air should be considered. For separation of product particles from air, air-product separators are used. Cyclones are mostly used to collect the particles. Cyclone is a device which removes the bulk of the product particle from the conveying air stream by centrifugal force. In some cyclone, a fabric filter is attached to remove residual dust and fine product particles from the air stream.

Limitations of Pneumatic Conveying

1. Erosion of solid surfaces and equipment surfaces by solid particles with conveying air stream.
2. In case of bends or misaligned sections, the erosion problem becomes severe.
3. Chances of repeated impacts between the particles and the solid surfaces are high. Due to such impacts, product degradation results.

Chain Conveyor

A chain is a reliable machine component, which transmits power by means of tensile forces, and is used primarily for power transmission and conveyance systems. The function and uses of chain are similar to a belt. Chains are divided into five types based on material of composition or method of construction.

1. Cast iron chain
2. Cast steel chain
3. Forged chain
4. Steel chain
5. Plastic chain