Belt Conveyors

Conveyors:

Simply, that convey material

Conveyors are mechanical devices or assemblies used to move items or packages with minimal effort. They usually consist of frames that support rollers, wheels, or belts and may be motor powered or manual devices.

Belt conveyors convey material with the help of belt

The belt of the conveyor may be of textile, strip steel, woven mesh steel wire.

- Conveyors with textile belt
- Conveyors with metal belt
- Chain driven and rope driven belt conveyors

N.B. Conveyors with rubberized textile belts have found the most extensive application.

Types of belt conveyors:

(i). According to the design
   a. Stationary conveyors
   b. Portable & mobile conveyors

(ii). According to the purpose
   c. General purpose conveyor
   d. Special purpose conveyor

Special purpose belts are used to convey hot loads or for operation at ambient temperature over +60°C and -25°C and also for the transport of material chemically injurious to the fabric or rubber cover of the belt. Special purpose belts include heat – resistant, frost resistant, and uninflammable and other types.

Geometry of belt conveyor:

According to their path of motion belt conveyors are classified as:

- Horizontal
- Inclined
- Combined
  - Inclined horizontal
  - Horizontal inclined
  - Horizontal inclined horizontal
  - Inclined horizontal inclined
Parts of belt conveyors:

1. **Belts:** Various types of textile belts are employed in belt conveyors: Camel hair, cotton (woven or sewed), duck cotton. Rubberized textile belts are widely used. Conveyors belts should meet the following requirements:

   1. Low hygroscopocity
   2. High strength
   3. Low own weight (Light in weight)
   4. Small specific elongation
   5. High flexibility
   6. High resistivity to ply (Layer of material)
   7. Long service life

Rubberized textile belts: Rubberized textile belts are made from several layers known as plies of a rough woven cotton fabric known as belling. The plies are connected by vulcanization with natural or synthetic rubber. Sometimes the plies are made of extra – strong synthetic fabrics, Capron, perlon, nylon etc.

2. **Idlers:** Generally the belt is supported by idler rollers, in rare cases by a solid wood, or sheet steel, runway or a combination support comprising sections of a runway alternating with idle rollers. Idlers are used mainly in conveyors handling bulk loads, less frequently unit loads, while runways and combined supports are predominantly used for piece goods.
According to their location on the conveyors, idlers are classified as upper (supporting the loaded strand of the belt) and lower (supporting the idler return strand of the belt).

3. Centering device: A number of reasons, such as eccentric loading, soiling, sticking of the material to the pulleys and rollers etc., may cause the belt to run crooked. To prevent the belt from running off the rollers, special “Belt training idlers” of various designs are used. These idlers automatically maintain belt alignment with respect to a device (idlers) called centering device.

4. Take ups: A belt conveyor may have a mechanical (screw type) or counterweight (gravity type) take up. The latter may in turn be divided into carries – type (sometimes called horizontal and vertical.

In the screw take up the tensioning pulley simultaneously serves as deflecting til or pulley and rotates on a fixed shaft (best design) or in terminal bearings (worst design).

In gravity take ups the tensioning pulley (serving simultaneously as tail and pulley) is placed on a movable carriage which is pulled backwards by means of a steel rope and deflecting pulleys.

The vertical counterweight take up consists of three pulleys, (two deflecting and one tensioning) and are installed on the return strand of the conveyor.

N.B. The carriage type take-up is superior to the vertical type because it is of much simpler design of considerably less height.
5. **Drive units:** In belt conveyors motive power is transmitted to the belt by friction as it wraps around the driving pulley rotted by an electric motor; the drive comprises the following parts: the pulley (Sometimes two pulleys), motor and the transmission gear between the motor and the pulley. Drives of inclined conveyors include a braking device which prevents slipping back of the loaded belt under the weight of the material conveyed if the current supplying the motor is interrupted.

6. **Loading & discharging:** Loading depends on the nature & characteristics of the load conveyed and the method of loading.

   Example: Charging
   
   For piece goods → various types of chutes are directly loaded onto the belt.
   
   For loose materials → feed hopper
   
   Discharging: Generally employed by
   
   - Scraper ploughs
   
   - A throw – off carriage known as tripper (only used for bulk materials)

   N.B.: The discharge plough is a board placed at a certain angle $\alpha$ to the longitudinal axis of the belt and fastened on a frame.

7. **Belt Cleaner:**

   In case of dry particles: The clinging dry particles are cleaned by scrapper/wiper
   
   In case of wet and sticky materials: Revolving brushes are used
   
   Scrappers are mounted on → end pulley
   
   Brushes are mounted on → lower num.

   Belt cleaners are mounted near the discharge pulley.
8. **Automated hold back brakes**: A sudden stoppage of a loaded inclined belt conveyor may cause slipping back of the loaded belt. This will happen if longitudinal component of load weight which is larger than the forces of frictional resistance to belt motion. To prevent this type of spontaneous movement of the belt, a special hold back brake is mounted on the main or auxiliary shaft which keep inclined in conveyor.

- It is a special protecting device which automatically disconnects the drive when the belt slips on the pulley.

9. **Conveyor frame**:

- It is a supporting structure of the conveyor & is usually electrical welded
- Consists of longitudinal beams, up-rights & cross pieces
- The height of the frame is usually 400 – 500 mm
- The spacing between upright is 2 – 3.5 m

**Application of belt conveyors**:

1. Convey great variety of unit loads & bulk loads
2. Foundry shop to convey mold or sand
3. Deliver fuel in power plant
4. Distribution of molding sand
5. Coal or ores mining
6. Cement & food industries
7. Carry articles of light weight in line production from one operation to another.

**Advantages of belt conveyors**:

1. High capacity 500-5000 m³/hour or more
2. Ability to transport loads for long distance (500-1000m or up)
3. Simplicity in design
4. Comparatively low in own weight
5. Reliable source
6. Convenient operation
7. Less skill required to operate
Disadvantages of belt conveyors:

1. Not suitable for hot ashes & slag.
2. Not suitable granular, powder
3. Abrasive material can cause defect in conveyor

Flight Conveyor

Ordinary solid flight conveyors consists of essentially of open trough secured on frame work, along with runs the putting member fitted the terminal sprockets & pulleys and takes its motion from drive unit & it initially tensioned by take up.

![Flight Conveyor](image)

Figure: Flight Conveyor

Working Principle

1. The material to be conveyed is loaded into the through at any point along the carrying run & is pushed by the flights.
2. Discharge can be effected at any point through openings in the trough, shut with gates or sliding doors.
3. Both the lower and upper strands of the conveyor can served as loaded stands.
4. When necessary it can convey materials simultaneously in opposite direction.

Application

1. Convey various powdered, granular & free flowing lump materials.
2. Mostly using coal mining operations.
3. Transport hot ashes & slug.
4. Special cable-disk conveyors are employed for handling piece goods such as wood, pulpwood etc.

Advantages

1. Simple design
2. Ability to convey in both direction.
3. Easy loading & unloading at any point along the conveying run.
Disadvantages

1. Crushing & breaking of the materials during transportation
2. Rapid wear of trough & moving parts.
3. Can not transport load for long distance (50-60m)
4. Low capacity & it is (150-200) tons per hour.

Different Parts of Flight of Conveyors

_Trough_: The Trough is a welded structure made of 4-6 mm sheet steel of rectangular or trapezoidal or of rolled profiles.

- Troughs may be stumped of sheet steel.
- In conveyors designed to handle light-weight materials (such as sawdust, grail etc.). The trough may be of wood.
- The clearance between flight & trough should be (3-6) mm.
- The trough is assembled of 4-6 m long sections.

_Drive Unit_: The drive unit is of the usual type, commonly supplied with a reducing gear.

- It’s duty to protect gear against breakages in case of an accidental overloads.

_Take Up Unit_: The take up chain & flight conveyors is of the screw or spring and screw type.

- The adjustment length should be nit less than 1.6 times the chain pitch.

_Frame Work_: The frame work of flight conveyors is generally welded of rolled profiles & assembled of separate sections.

_Flights_: Flat rectangular flight symmetrically fastened on roller chains to carry the flights have found the most extensive application.

- Are one of the most frequently used types is the box-type flight conveyor with having longitudinal slide plates.

_Pulling Member_: The reliable and effective operation & long service life of a conveying machine will be ensured if the pulling member wraps freely around drums, sprockets & pulleys of small diameter.

- Combines high strength & low weight.
- The conveying machine without a pulling member will not fit into general classification as they have no identical purpose.

_Difference between belt conveyor & flight conveyor_

<table>
<thead>
<tr>
<th>Belt Conveyor</th>
<th>Flight Conveyor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Ability to convey in one direction.</td>
<td>2. Ability to convey in both direction.</td>
</tr>
<tr>
<td>3. Loading and unloading takes place at the specified position/fixed point.</td>
<td>3. Easy loading &amp; unloading at any point.</td>
</tr>
<tr>
<td>4. Can transport load for long distance (500-1000m or more).</td>
<td>4. Can not transport load for long distance (50-60m).</td>
</tr>
<tr>
<td></td>
<td>High capacity.</td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Comparatively low in own weight.</td>
</tr>
<tr>
<td>7</td>
<td>Less skill required to operate</td>
</tr>
</tbody>
</table>

**Screw Conveyor**

![Screw Conveyor](image)

**Application**
- Convey small lumped/dry, granular, powder material.
- Convey non abrasive material.
- Convey non packing material.
- Convey non sticky material.

**Advantages**
- Small space required.
- Simplicity of design.
- Easy to maintain.
- Small width.
- Permit intermediate discharge of the material.
- Can convey dusty and hot material.
Disadvantages

- Carry only non-packing material.
- High power consumption.
- Rapid wear of the screw parts.
- Crushing and breaking of material.
- Used for low & medium capacity (up to 100 m³/hr.).
- Can not convey load for long distance.

Different Types of Screw

1. Solid Continuous: Mainly used for granular powdered material.
2. Ribbon: used for lumpy material.
4. Cut Flight:

Vertical Screw Conveyor

- It consists of the continuous screw vertically suspended from the thrust bearing & cylindrical casing.
- There are no intermediate bearings.
- The conveyor is fed by short horizontal screw which forces the material into the lower part of the casing.

Example-4 : page-276.
Hydraulic Conveyor

*Hydraulic Conveyor:* Hydraulic conveying consists in moving bulk materials along pipes or troughs (channel) in a stream of water.

![Hydraulic Conveyor](image)

**Figure: Hydraulic Conveyor**

**Principle**
- The mixture of material & water is generally termed as pulp.
- In pressure conveying systems the pulp is moved by the pressure created by a natural difference in levels or by means of mechanical devices (pumps, hydraulic elevators etc.).
- In trough (channel) and gravity-flow systems it flows down an incline.

**Application**
- Various branches of industry and construction work.
- Electric power plant for ash & slug from boiler room.
- Mining operation.
- Digging up the river.

**Advantages**
- Long conveying run.
- High capacity.
- Comparatively simple equipment required.
- Low running cost
- Transportation can be combined with certain technological process (such as quenching, washing, cooling etc.)

**Disadvantages**
- Increase air humidity when operating in closed premises.
- Freeze the water under low ambient temperature.
- Limited number of materials that may be transported in water.
- High water consumption.
Pneumatic Conveyor

Pneumatic or air conveyor serves to convey bulk materials (or unit loads in special carries) in a stream of air moving through a duct.

The operating principle common to all types of pneumatic handling installations is that motion is imparted to the load by a front moving stream of air.

Parts

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw feeder</td>
<td>Airslide</td>
</tr>
<tr>
<td>Conveying pipe</td>
<td>Blowers</td>
</tr>
<tr>
<td>Silos</td>
<td>Self-unloading hopper</td>
</tr>
<tr>
<td>Change over valves</td>
<td>Intermediate hopper</td>
</tr>
<tr>
<td>Level indicators</td>
<td>Concrete plant hopper</td>
</tr>
<tr>
<td>Dust Collector</td>
<td>Compressor</td>
</tr>
<tr>
<td>Discharge gates</td>
<td>Air header</td>
</tr>
<tr>
<td>Aerating Plates</td>
<td>Moisture trap</td>
</tr>
</tbody>
</table>

Application/Use

- Industries, construction works, silos of plants, rail and water transport.
- Convey variety of dry & free flowing and powdered materials.
- Used to convey cement, coal dust, saw dust.
- Bulk materials within shop and stores.

Advantages

Pneumatic conveyors transporting materials in a steam of air have a number of significant advantages, namely:

- The materials are transported in a hermetically sealed pipe and loses are obviated.
- Economical in space.
- Easy to automation.
- Can operate for a long distance.

Disadvantages
- High power consumption.
- Sticky materials can not be transport.
- Not suitable for moist parking.
- The noise of blower is so large.

Bucket Elevator

Used to pull an object up to a certain height.

Working principle
Charge/Load: Here, no extra force is needed to collect the bulk material. Only gravitational force is acting on the material.
Parts of the Bucket elevator:
1. Chain
2. Buckets
3. Drive Sprockets
4. Take up
5. Upper casing section

Types:
1. Spaced bucket
2. Continuous bucket

Advantages:
- Capacity (5-160) m³/hr.
- Smooth transportation of goods
- Less maintenance required
- Long service life
- Low driving power
- Transverse compactness
- Ability to raise load up to 50m in height

Disadvantages:
- Very sensitive to overload
- Must be loaded at a uniform rate

Application:
- Used to convey materials in foundry shop
- Convey various powder
- Granular and lumpy material
- Chemical and food industry

Charge & discharge of the buckets:

<table>
<thead>
<tr>
<th>Charge</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scooped</td>
<td>1. Gravity</td>
</tr>
<tr>
<td>Direct fed</td>
<td>2. Centrifugal force</td>
</tr>
<tr>
<td></td>
<td>3. Direct gravity</td>
</tr>
</tbody>
</table>
Prove that pole distance of a bucket elevator depends upon the rpm of the pulley.

The bucket is going up because of centrifugal force.

\[ m = \text{mass of the load containing in the bucket} \]
\[ v = \text{speed of the center of gravity of load in bucket (m/s)} \]
\[ r = \text{radius of rotation} \]

Force of gravity, \( P = mg \)
Centrifugal force, \( F = \frac{mv^2}{r} \)

Similar triangle, ABO & AFR

\[ \Rightarrow \frac{AF}{FR} = \frac{OA}{OB} \]
\[ \Rightarrow \frac{F}{R} = \frac{r}{l} \]
\[ \Rightarrow \frac{l}{r} = \frac{mg}{\left(\frac{mv^2}{r}\right)} \quad [v = \frac{\pi rn}{30} \text{ or, } v = \frac{2\pi rn}{60}] \]

So, \( l = \frac{g r^2}{v^2} = \frac{895}{n^2} \)
GENERAL THEORY OF CONVEYING MACHINE

Capacity, \( Q = \text{load per metre of machine length} \times \text{Rate of conveyor} \)

\[
q = q \times v \text{ kg/s}
\]

\[
= \frac{3600}{1000} qv \text{ tons per hour} \quad \text{(1)}
\]

Hourly capacity = 3.6 \( qv \) tons/hour

For the bulk load

If the load has a bulk weight of \( r \) tons per cubic m and is conveyed in a continuous stream having a cross sectional area of \( F \) square m, then

\[
q = 1000 Fr \ (\text{tons/m}^3) \times m^2
\]

\[
= Fr \text{ tons/m}
\]

\[
= 1000 Fr \text{ kg/m} \quad \text{(2)}
\]

When the material is conveyed in a trough or tube having cross sectional area of \( F_0 \) sq m.

loading efficiency (\( \Psi \))

Then,

\[
F = F_0 \Psi
\]

\[
q = 1000F_0 \gamma \Psi \quad \text{-------- (3)}
\]

When the material is moved in separate container each having a volume \( i_0 \) liters, filled to a capacity of \( i \) liters and the containers are spaced \( a \) meters apart.

\[
q = i \gamma /a
\]

\[
= i_0 \Psi \gamma /a \text{ kg/m}
\]

For unit loads

If the unit loads having a weight of \( G/\text{kg} \) each are conveyed in lots of \( z \) pieces and the spacing between the units or lots is \( a \) meters

\[
q = G/a \quad \text{kg/m}
\]

Or, correspondingly, \( q = Gz/a \)

Substituting the value of \( q \) in equation (1)

\[
Q = 3.6qv \text{ tons/hr}
\]

\[
= 3.6 \times (Gz/a) \times v \text{ tons/hr} \quad \text{[for unit loads]}
\]
Now, material in a container stream
\[ Q = 3.6 \times 1000 \, h \Psi \gamma \times v \]  
(from equation 1)

For separate containers,
\[ Q = 3.6 \, (i/a) \, v \, \gamma \]
\[ = 3.6 \, (i_{0}/a) \, v \gamma \Psi \]  
(from equation 1)

## If the time interval between separate loads or lots is \( t_{1} \) sec, then the capacity per hour
\[ Q = \frac{G}{1000} \times \frac{3600}{t_{1}} = 3.6 \, (G/a) \, v = 3.6 \, (G/a) \, (a/t_{1}) \quad [v = (a/t_{1}); \, t_{1} = (a/v)] \]
\[ = 3.6 \, (G/t_{1}) \]
\[ = 3.6 \, (Gz/t_{1}) \quad [\text{If } z = \text{lot size}] \]

The capacity of continuous conveying machine is sometimes expressed by the number of pieces conveyed per hour.

Hence the hourly capacity is
\[ Z = \frac{3600}{t_{1}} = 3600v/a \quad [t_{1} = a/v \text{ sec}] \]

Or, when lots of \( z \) pieces are conveyed
\[ Z = 3600zv/a \]

If the \( G \) is the weight of a separate load in kg, the capacity expressed in units of weight is
\[ Q = \frac{Gz}{1000} \text{ tons per hour} \]

### Resistance to motion factor:

(Write down introductory sentences and define the symbol)

Effective power on lifting the load
\[ Q = \text{tons/hour} \]
\[ N_{\text{eff}} = \frac{1000QH}{(3600 \times 75)} = \frac{QH}{270} \text{ hp} \]

Or, \( N_{\text{eff}} = \frac{1000QH}{3600 \times 102} = \frac{QH}{367} \text{ kw} \)

The required motor power
\[ N = \frac{N_{\text{eff}}}{\eta} = \frac{QH}{270\eta} \text{ hp} = \frac{QH}{367\eta} \text{ kw} \]

Here, \( \eta = \text{conveying efficiency} \)

The above equation can not be used to determine required motor power of horizontal conveying machine. (See book Page - 27)
Frictional resistance

\[ W_{\text{fric}} = qLw \text{ kg} \]

The power required to overcome frictional resistance is,

\[ N_{\text{fric}} = \left( W_{\text{fric}} \ast v \right)/75 = qLw/v/75 \text{ w=friction factor} \]
\[ = QLw/(75 \ast 3.6) = QLw/270 \text{ hp L = path length} \]

\[ N_{\text{fric}} = QLw/367 \text{ kw} \]

The total power consumption

\[ N = N_{\text{eff}} + N_{\text{fric}} \]
\[ = (QH/270) + (QLw/270) \text{ hp } \text{----------- ( *)} \]
\[ = (QH/367) + (QLw/367) \text{ kw } \text{----------- ( *)} \]

The power is determined not for the engine shaft but for the driving (main) shaft of the conveying machine. It’s value will be

\[ N_o = N_{\text{eff}} + N_{\text{fric}} \]
\[ = (QH/270) + (QLw_o/270) \text{ hp} \]
\[ = (QH/367) + (QLw_o/367) \text{ kw} \]

\[ w_o = \text{Frictional resistance of all parts of conveying machine} \]

Except that of the transmission gear the values of \( N \) & \( N_o \) are related

Since, \( N = N_o / \eta_g \), Here, \( \eta_g = \text{Efficiency of the transmission gear} \)

For horizontal conveying machine, \( H = 0 \)

\[ N = N_{\text{fric}} + N_{\text{eff}} = 0 \]
\[ = (QLw/270) \text{ hp} \]
\[ = (QLw/307) \text{ kw} \]

For vertical device, \( (L = H) \)

\[ N = (QH/270) (1+w) \text{ hp} \]
\[ = (QH/307) (1+w) \text{ kw} \]

Comparing relation with (*),

\[ (1/\eta) = 1+w \]

So, Decrease in resistance to motion factor results in an increase in efficiency
Example 1

\( Z = 1600 \text{ parts/hour} \quad L = 60 \text{ m} \)

\( b = 220*b_1 = 180 \text{ mm} \)

\( G = 10 \text{ kg} \quad \text{(piece weight)} \)

The conveyor is horizontal

(1) Main parameters of the conveyor

The belt width

\[ B = b + 2*90 = 220 + 180 = 400 \text{ mm} \]

(Take help from figure)

Belt speed \( \Rightarrow v = 0.5 \text{ m/s} \)

Idler spacing on the loaded strand \( u = 1.4 \text{ m} \)

On the idle strand, \( l_2 = 2.8 \text{ m} \)

# Maximum theoretical capacity

\[ z_{\text{max}} = zk' = 1600*1.25 = 2000 \text{ pieces/hour} \]

\[ Q = Gz_{\text{max}} / 1000 = 20 \text{ tons/hour} \]

At maximum load the distance between separate unit loads

\[ A = (3600v) / z_{\text{max}} = (3600*0.5) / 2000 = 0.9 \text{ m} \]

Loads per running metre

\[ q = G/a = 10/0.9 = 11.1 \text{ kg/m} \]

Weight of the belt per metre of its length

\[ q_b \cong 1.1B(\delta_1 + \delta_1 + \delta_2) \]

Weight of the idler rotating parts

\( Gp \quad q_1 \text{ and } q_2 ?? \)