SCREW CONVEYOR

1. Definition, Characteristics and Use

A screw conveyor consists of a continuous or interrupted helical screw fastened to a shaft which is rotated in a U-shaped trough to push fine grained bulk material through the trough. The bulk material slides along the trough by the same principle a nut prevented from rotating would move in a rotating screw. The load is prevented from rotating with screw by the weight of the material and by the friction of the material against the wall of the trough.

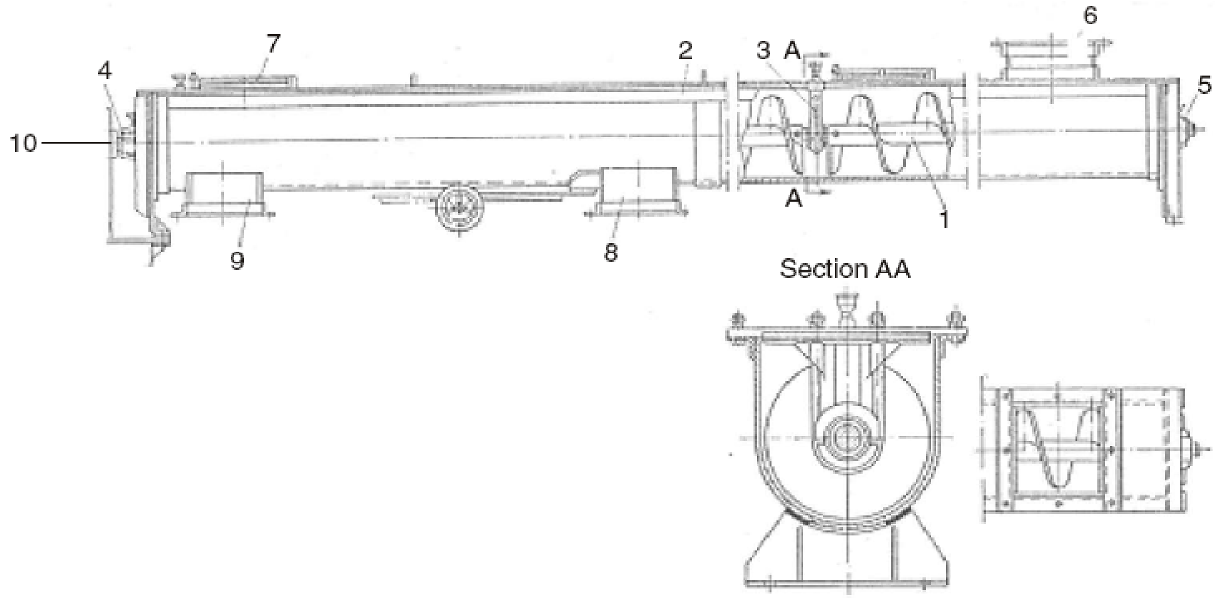
A screw conveyor is suitable for any pulverized or granular non viscous material, and even at high temperature. The conveyor is particularly suitable for mixing or blending more than one materials during transportation, and also for controlling feed rate of materials in a processing plant. Abrasion and consequently certain amount of degradation of the material is unavoidable, hence it is not suitable for brittle and high abrasive materials. It is also not suitable for large-lumped, packing or sticking materials.

Go to the outline

2. Descriptive Specifications

A typical screw conveyor is shown in Fig. 1. The screw shaft, if short (up to 5 meters), is supported at two ends. But for longer shafts (upto 40 to 50 m), they are supported by bearing hangers, at intermediate points. The shaft may be solid or hollow. Hollow shafts are lighter and can be easily joined to make a long shaft. The screw shaft is driven at one end, and the design may permit discharge of material from the bottom or one end. Opposite handed screw at two sides will cause the center discharge.

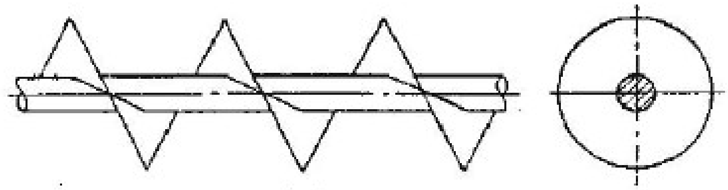
The U-shaped fabricated trough are generally covered at the top to avoid particulate pollution. The bottom portion of the trough is of circular cross section matching the diameter of the screw. Generally a radial gap of 10 mm to 20 mm is kept between the screw and the trough, depending on size of the screw.



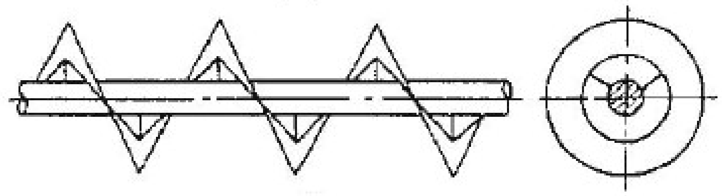
1-shaft with screw; 2-trough; 3-Intermediate hanger bearings; 4-front bearings; 5-terminal bearing; 6-feed hopper; 7-sight glass; 8-Intermediate discharge spout with gate; 9-terminal discharge hopper (open); 10-drive system (motor, gear box and coupings)

Fig. 1. Arrangement of a screw conveyor

Screws of different constructional design and style are used, which are shown in Fig. 2. Continuous screws are generally made from 4 to 8 mm sheet steel circular section with a hole corresponding to the size of the shaft. One radial slit is made in this section, and then formed into one pitch of the screw. The section is welded to the shaft and welded or riveted to each other to form the entire length of the screw. The screw may also be cast integral with the shaft. The paddle type flights consist of cast straight or curved segments fixed to the shaft. A ribbon screw is fixed to the shaft by means of radial rods.



(*a*)



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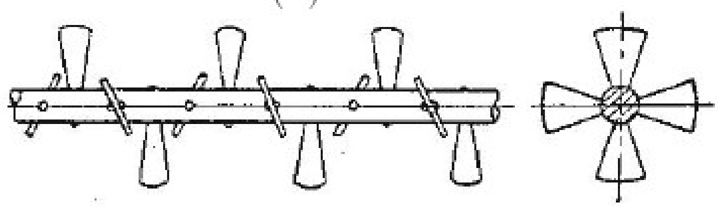
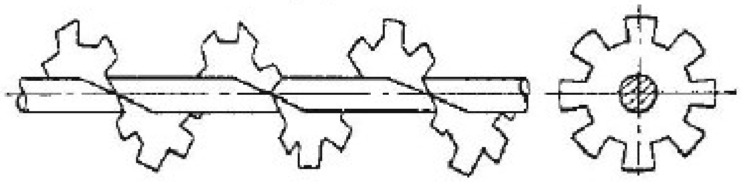
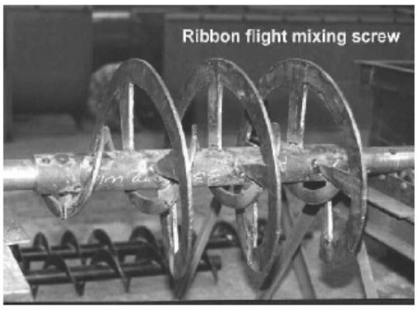


(*c*)



(*d*)

(*a*) solid, continuous; (*b*) ribbon; (*c*) paddle-flight; (*d*) cut-flight



photographs of different types of screw

Fig. 2. Types of screw used in screw conveyor

The drive unit comprises of an electrical motor, gear box and couplings. Material is fed through the feed hopper fixed on the trough cover. A number of discharge sprouts with rack gears for closing and opening as required, are provided. Screw conveyors are generally operated horizontally or at a small inclination (10° to 20°). However, there are special designs where the load is moved vertically up or at a small angle to vertical. These are called vertical screw conveyors.

Go to the outline

3. Aspects of Screw Conveyor Design

Recommended Dimension of a Screw Conveyor: The dimensions of principal components of a screw conveyor are nominal diameter of the helical screw, pitch of the screw, diameter of screw shaft, width of trough determining the gap between trough and screw, trough height from center of screw shaft, thickness of trough material and nominal thickness of screw flights.

Indian standard specification IS:5563:1985 has specified the standard dimensions for all above components. The recommended dimensions as per above IS is given below. The notations used in the table are shown in Fig. 3.

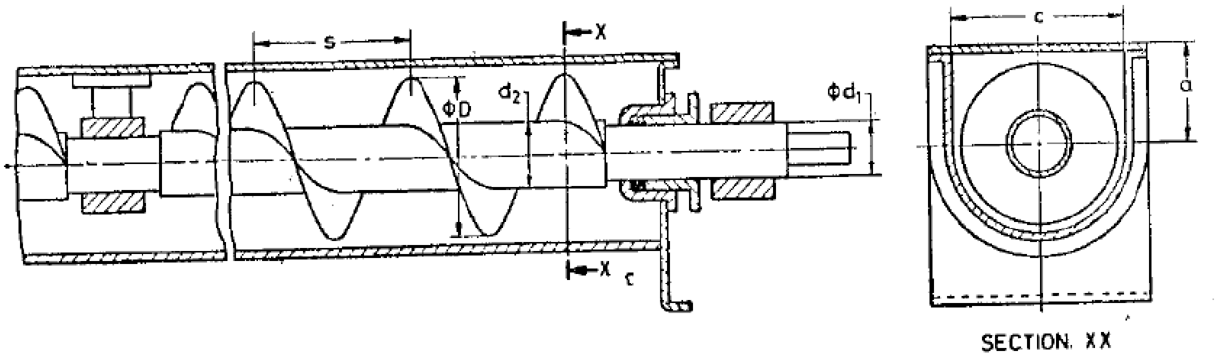


Fig. 3. Explanatory sketch for table 1

However, does not include the standard values of screw pitches. There are given below in mm: 80 100 125 160 200 250 315 400 500 600. Value of screw pitch ‘S’ generally varies between 0.8 to 1.0 time diameter 'D' of the screw. Screw pitch equal to the screw diameter is commonly used.

Table 1. Recommended Dimensions of Screw Conveyors

Nominal size D	Trough Height from Centre of Screw Shaft to Upper Edge of the Trough (a)	Trough Width C	Thickness of Trough			Tubular Shaft d_2) × Thickness*	Outside Diameter of Solid Shaft	Coupling Shaft Diameter	Nominal Thickness of Helical Screws					
									Segmental root			Continuous root		
			Heavy Duty	Medium Duty	Light Duty				Heavy	Medium	Light	Heavy	Medium	Light
100	63	120	----	2.0	1.6	33.7 × 2.5	30	25	----	3.15	2.0	----	5.0	3.15
125	75	145	----	2.0	1.6	33.7 × 2.5	30	25	----	3.15	2.0	----	5.0	3.15
160	90	180	5.0	3.15	1.6	42.4 × 2.5	35	40	5.0	3.15	2.0	7.0	5.0	3.15
200	112	220	5.0	3.15	2.0	48.3 × 3.5	40	40	5.0	3.15	2.0	7.5	5.0	3.15
250	140	270	5.0	3.15	2.0	60.3 × 4.0	50	50	6.0	5.0	3.15	10.0	7.0	5.0
315	180	335	5.0	3.15	----	76.1 × 5.0	60	50	7.0	5.0	3.15	10.0	7.0	5.0
400	224	420	5.0	3.15	----	76.1 × 5.0	60	75	8.0	6.0	5.0	12.0	10.0	7.0
400	224	420	5.0	3.15	----	88.9 × 5.0	70	75	8.0	6.0	5.0	12.0	10.0	7.0
500	280	530	5.0	3.15	----	88.9 × 5.0	70	75	8.0	7.0	5.0	----	----	----
500	280	530	5.0	3.15	----	114.3 × 5.5	80	75	8.0	7.0	5.0	----	----	----
630	355	660	6.0	5.0	----	114.3 × 5.5	80	100	10.0	8.0	----	----	----	----
630	355	660	6.0	5.0	----	139.7 × 6.0	90	100	10.0	8.0	----	----	----	----
800	450	830	6.0	5.0	----	139.7 × 6.0	90	100	10.0	8.0	----	----	----	----
800	450	830	6.0	5.0	----	152.4 × 7.0	100	100	10.0	8.0	----	----	----	----
1000	560	1040	7.0	5.0	----	152.4 × 7.0	100	125	12.0	10.0	----	----	----	----
1000	560	1040	7.0	5.0	----	193.7 × 8.0	110	125	12.0	10.0	----	----	----	----
1250	710	1290	7.0	5.0	----	193.7 × 8.0	110	150	12.0	10.0	----	----	----	----

**Tubular shaft diameter d2 has been taken preferably from IS:3501:1966 (all dimensions in mm)*

Effect of Lump Size: The selection of size of a screw conveyor basically depends on two factors. (*i*) the conveying capacity required and (*ii*) the lump size of the materials to be conveyed. The lump size of materials determines the minimum size of the screw diameter 'D' to be chosen. D is recommended to be at least 12 times the lump size of a sized material or at least 4 times the largest lumps of an unsized material.

Go to the outline

4. Capacity of Screw Conveyor

The volumetric capacity ‘V’ in M3/Hr depends on screw diameter ‘D’ in meters, screw pitch ‘S’ in meters, its rotational speed ‘n’ rpm and the loading efficiency of the vertical cross sectional area ‘φ’.The tonnage capacity ‘Q’ in tons/hr is given by:

$$Q = V\gamma = \frac{\pi D^2}{4} S\ 60 n \phi \gamma C \text{ tons/Hr.}$$

where γ = bulk density of material in tons per m^3

C = factor depending on inclination of conveyor.

In a typical design , S = D to 0.8 D.

ϕ varies with flowability of the material as under:

Material Characteristics	Value of φ
1. Slow flowing, abrasive (clinker, ash)	0.125
2. Slow flowing, mild abrasive	0.25
3. Free flowing, mild abrasive (sand)	0.32
4. Free flowing, non-abrasive (grain)	0.4

Value of 'C' varying with inclination angle β is related as shown in following chart.

β	0°	5°	10°	15°	20°
C	1.0	0.9	0.8	0.7	0.65

The screw diameter and speeds vary widely depending on the designed capacity of the conveyor and the nature of the material handled. However, the speed is generally reduced as the diameter goes up, as shown in following table:

Screw dia, mm	160	200	250	300	400	500	630
Maximum rpm	150	150	120	120	95	90	75
Minimum, rpm	25	25	20	20	20	15	10

[Go to the outline](#)

5. Power Requirements of Screw Conveyor

IS:12960:1990 "Determination of Power Requirement of Screw Feeder—General Requirements", has recommended the method for calculation of power requirement of a screw conveyor.

The driving power of a loaded screw conveyor may be estimated by the formula:

$$P = P_H + P_N + P_{st}$$

where, P_H = power necessary for conveying the material.

P_N = driving power of the conveyor at no load.

P_{st} = power requirement for inclination of the conveyor.

Power necessary for conveying the material: P_H in kW is the product of the mass flow rate 'Q' of the material, the length 'L' of material movement in the conveyor and an artificial frictional coefficient 'λ', also called progress resistance coefficient.

$$P_H = \frac{QL'}{3600} \lambda g, \text{kW} = \frac{QL'\lambda}{367}, \text{kW}$$

where, Q = mass flow rate in t/hour.

L′ = length of material movement in conveyor in m.

λ = progress resistance coefficient.

λ depends on the material and its size. It is generally of the order of 2 to 4. It should be noted that during progress of material, over and above of sliding between the material, trough and screw, the material particles slide against each other which results in internal friction. Therefore, λ is naturally expected to be more than normal coefficient of friction for the material.

Drive power of the screw at no load, P_N is comparatively low. It is proportional to the screw diameter and total length of the screw. The recommended formula is

$$P_N = \frac{DL}{20}, \text{kw}$$

Where, D = Nominal screw diameter, m

L = Length of screw, m

Power due to inclination, P_{st}. This power requirement is the product of the mass flow rate and height to which the material is being conveyed. Thus

$$P_{st} = \frac{QHg}{3600} = \frac{QH}{367}, \text{ kW}$$

Where, Q = mass flow rate in t/hr.

H = height in m.

If material is moving down the inclination, H is to be taken as negative. So, total power requirement is

$$P = \frac{Q(\lambda L' + H)}{367} + \frac{DL}{20}, \text{ kilowatts.}$$

Go to the outline