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✰ STUDY ON FILLING FACTOR OF SHORT LENGTH SCREW CONVEYOR WITH FLOOD-FEEDING CONDITION

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Abstract

Screw Conveyor is one of the best conveying systems in specific application areas, like mass flow rate less than 1200 t/h while free flowing material as conveying material and it can employed for transportation of pulverized, granular, small-sized lumpy wide range of bulk materials to relatively short distance (Usually up to 40 m for horizontally or to a height up to 30 m). The screw conveyor is a very simple construction with only one moving part, the screw itself with easy maintenance and convenient for intermediate unloading. A screw conveyor can be used for conveying and mixing or blending for more than one material during transportation. To investigate the performance characteristics during transportation of material using continuous type of screwat various speeds, a laboratory sized short length screw conveyor is designed and got fabricated by a suitable vendor.

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Keywords: Screw Conveyor; flood-feeding condition; filling factor

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1. INTRODUCTION

The basic working principle of conveying within screw type conveyors is that, as the screw rotates, the material is propelled along the screw shaft, as a nut would be moved on a threaded bar if restrained from rotating together with the bar. Rotation of the material together with the screw is prevented by its gravity force and friction on the trough walls.

The specified screw conveyor and VFD along with instrument panel is installed in the laboratory of Mechanical engineering department (NITTTR Kolkata) to run the screw at variable speed for experimental purpose. The typical experimental set up along with screw conveyor is shown in figure 1. Near the rear end (non drive end) a suitable wooden platform is placed in front of the conveyor, ensuring an operator to feed the material manually into the replaceable feed hopper placed on top of U trough.

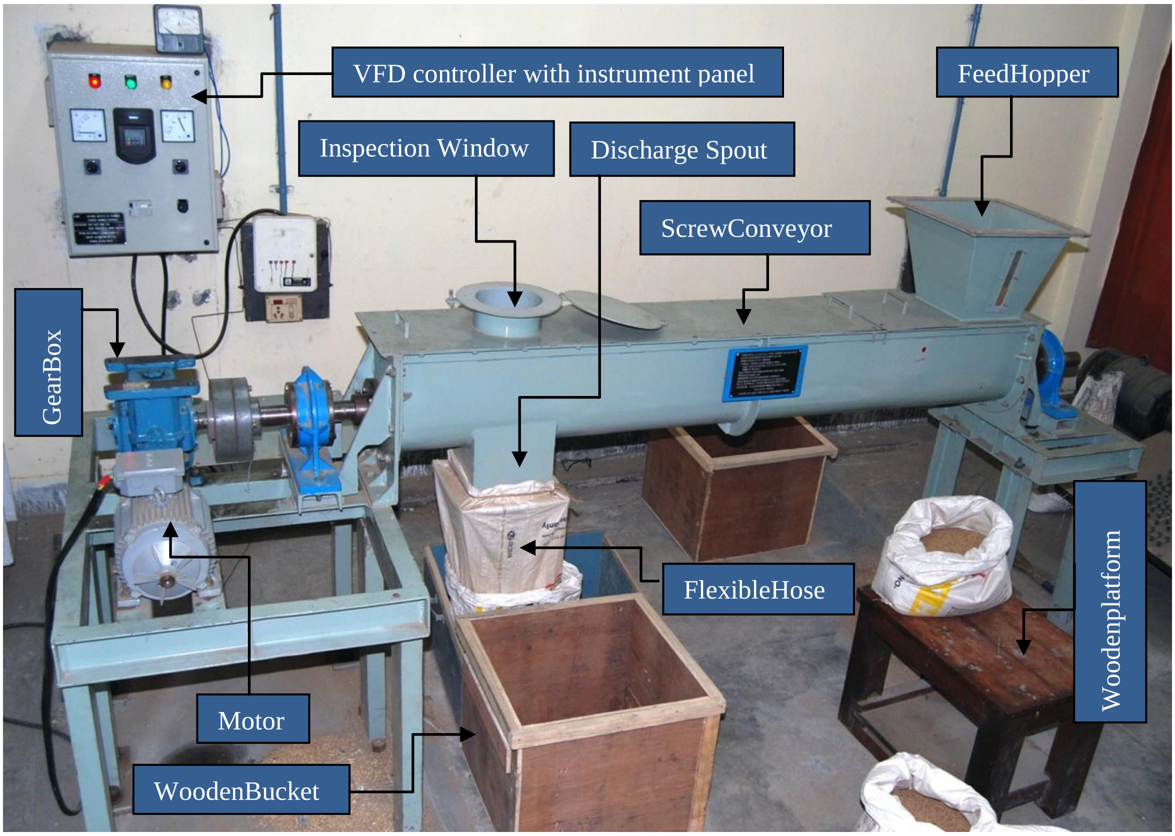

Figure 1: view of the experimental Screw Conveyor set-up.

At the front plate of the trapezoidal shaped feed hopper a slit, covered by a transparent plastic sheet is made to see the material fill level in hopper. Two wooden buckets are placed side by side under the outlet spout of the conveyor. A flexible hose is connected with the outlet spout to direct the conveyed material into any one of the buckets.

An electronic weighing machine of 50 kg capacity with minimum resolution of 1 gram is used for weighing the conveyed materials. A stop watch is used for measurement of time. Sufficient quantity of dry coarse sand is filled into bags for doing experiment with same as conveying material.

2. Experimental Procedures:

The major objective of the present research work is to determine the **filling factor** of dry coarse sand in a short length screw conveyor while using continuous type of screw and different screw speeds, and to investigate whether this filling factor is dependent on screw speed or not .

Another objective is to study the effect of constant trough height from centre of screw shaft on filling factor for a short length screw conveyor with flood-feeding condition. However the experiment is conducted with a particular type of screw(continuous type) at various speed.

The mass flow rate of a conveyed material in a screw conveyor depends on this filling factor as given by the following formula

$$Q = (\pi \times D^2 \times S \times 60 \times n \times \Psi \times \gamma \times C)/4 \quad \text{tons/hr} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(Eq.1)}$$

Where, Q = mass flow rate in tons/hr.
Ψ = Filling factor
D = Nominal diameter of the Screw in m.=0.2 m
S = Pitch of the screw in m.=0.16m
γ = Bulk density of conveyed material in tons/m³ =1.572 tons/m³
C = Inclination factor, for horizontal screw conveyor it's value is "one"
n= speed of the screw in rpm

It is proposed to determine filling factor from the equation 1. The mass flow rate, 'Q' is measured for each individual runs. After filling the conveyor with dry sand, the conveyor is started and speeded up to the specific screw speed by controlling the VFD controller push button switch and allowed to run at that speed for about 5 seconds. During this 5 seconds stabilization of speed is achieved and conveyed material is collected in the bucket (Bucket No.1). At this instant the output of the conveyor is manually switched over to the second empty bucket (Bucket No.2) and the commencement of measurement of time is started by operating a stop watch. After passage of predetermined time (30 seconds for each run for this set of experiments), the output is again switched over to the first bucket (Bucket No.1).

The total weight of the conveyed material at a particular stabilized screw speed during the measured period, stored in the second bucket (Bucket No.2) is measured and with the help of weighing scale and mass flow rate in tons per hour is calculated.

The arrangement of switching of the output by switching the flexible delivery hose is found to be necessary for two reasons: (i) For stabilization of the conveyor at a definite screw speed and (ii) It is found that even after stopping of the conveyor, a substantial amount of material comes out from the conveyor through the delivery spout due to inertia. The quantity of this extra material is also not constant as it depends upon the relative position of the screw flights with respect to the discharge spout opening when the conveyor stops. As this quantity is not negligible compared to the quantity of material conveyed during operating time (30 Seconds run), this extra material is not allowed to get collected in the same bucket (Bucket No.2) by switching output, just after 30 seconds to another bucket (Bucket No.1).

Prior to these experiments bulk density of dry sand is measured experimentally. From equation (1) filling factor for conveying material is determined by substituting the mass flow rate, experimental bulk density of sand, screw r.p.m, screw pitch and screw diameter.

During each experimental run, one person of the three members team, continuously poured the raw material at the feed hopper and ensured that the hopper was always full beyond a minimum level (flood feeding condition)so that the conveyor delivery rate is not affected because of material shortage.

The conveying length L′ is kept constant during experimental runs, which is the distance between the center lines of the feed hopper fixed at a particular position over the trough to the nearest inner edge of the delivery spout. This is measured to be 1.48 m.

Readings are taken for dry sand at four different screw speeds of 12, 15, 21, and 26 rpm.

The maximum screw speed of 26 rpm and the duration of 30 seconds for each experiment are fixed basically from the consideration of capacity of manual feeding to cope up with the mass flow rate. This was established by initial trial runs of the conveyor at different screw speeds. Other three lower speeds are chosen arbitrarily keeping in view of getting distinct results to study effect of speed.

At lowest speed of 12 rpm, readings are also taken for run period of 60 seconds for conveyed materials, to ensure that there is no appreciable difference in the mass flow rates measured during 30 seconds or 60 seconds run time.

Table 1: Experimental data sheet

Sl. no.	Frequency (f) in Hz	Speed of screw (n) in (rpm)	Operating time (t) in seconds	Amount of material conveyed (kg)	Average amount of material conveyed (M) (kg)	Mass flow rate (Q) in tons/hr	Volumetric capacity (V) in m^3 / min	Filling factor (Ψ)
1	10	12	30	35.395	35.97	4.32	0.05	0.76
2	10	12	30	36.570				
3	10	12	30	35.960				
4	10	12	30	35.960				

5	12.5	15	30	46.780	46.70	5.60	0.06	0.79
6	12.5	15	30	47.785				
7	12.5	15	30	45.540				
8	12.5	15	30	46.695				
9	17.5	21	30	65.640	65.68	7.88	0.08	0.79
10	17.5	21	30	65.680				
11	17.5	21	30	65.725				
12	17.5	21	30	65.685				
13	21.7	26	30	83.775	83.36	10	0.1	0.81
14	21.7	26	30	82.940				
15	21.7	26	30	83.350				
16	21.7	26	30	83.365				

Experimental run using a particular type of screw running at a particular speed is repeated four times and the average of the four runs are taken to minimize experimental error.

Type of screw: Continuous type Type of conveying material: Dry coarse sand

Experiment performed: With trough cover having height of trough cover from centre of

Screw 112 mm

The conveying length L′ is kept constant during experimental runs, which is the distance between the center lines of the feed hopper fixed at a particular position over the trough to the nearest inner edge of the delivery spout. This is measured to be 1.48 m.

Readings are taken for dry sand at four different screw speeds of 12, 15, 21, and 26 rpm, using three different types of screw, one at a time.

The maximum screw speed of 26 rpm and the duration of 30 seconds for each experiment are fixed basically from the consideration of capacity of manual feeding to cope up with the mass flow rate. This was established by initial trial runs of the conveyor at different screw speeds. Other three lower speeds are chosen arbitrarily keeping in view of getting distinct results to study effect of speed.

At lowest speed of 12 rpm, readings are also taken for run period of 60 seconds for conveyed materials, to ensure that there is no appreciable difference in the mass flow rates measured during 30 seconds or 60 seconds run time.

Each experimental run using a particular type of screw running at a particular speed is repeated four times and the average of the four runs are taken to minimize experimental error.

3. CONCLUSION

From the results obtained through series of experiments as contained in Tables the following conclusions are made:-

i) With the constant height (112 mm) of trough cover, the filling factors are almost constant within the range of speed of 15 to 21 r.p.m.. For continuous type screws the filling factor (Ψ) varies within a range of 0.76 to 0.81. These variations are attributed to different throughput capacities at different speeds.

ii) The high value of filling factor is due to the fact that the feeding condition was flood-feeding and length of the screw was short and without any obstruction of bearing hanger. This is quite in line with general observation that the filling factor is about double in case of short length screw conveyors compared to that of a long one. (Reference: Materials Handling Equipment by Alexandrov, M.P.)

iii) In flood feeding, the input material submerges the entire screw as the material moves over the top of the screw in the vicinity of the feeding point. The height of the material settles to a definite height after it crosses the first bearing hanger. Therefore, the effective filling factor is much smaller in long screw conveyor even with flood feeding condition.

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