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Research Article

Study on Filling Factor of Short Length Screw Conveyor with Ribbon Type Screw at Two Different Trought Height (112 mm & 180 mm) in Flood-Feeding Condition

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Abstract

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 Ribbon type of screw at different screw speeds, and to investigate whether this filling factor is dependent on screw speed or not along with the variation of filling factor at two different trough height is also investigated. Another objective is to study the effect of two different constant trough heights 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 (ribbon type) at various speeds.

Keywords: *Conveyor, flood-feeding condition, filling factor, ribbon type screw.*

1. Introduction

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. 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) (Nagel, 1968). To investigate the performance characteristics during transportation of material using ribbon type of screw at various speeds, a laboratory sized short length screw conveyor is designed and got fabricated by a suitable vendor.

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 (Fuchs et al., 2007), (Fottner and Johannes, 2000). 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 (Roberts, 1999), Yu and Arnold, 1996).

2. Experimental Procedures

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

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

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

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Ψ = Filling factor
D = Nominal diameter of the Screw = 0.2 m
S = Pitch of the screw = 0.16m
Γ = Bulk density of conveyed material =1.572 tons/m^3
C = Inclination factor, for horizontal screw conveyor its 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 button switch and allowed to run at that speed for about 5 seconds. During these 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. 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 rpm, 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. Experiments are conducted using ribbon type of screw with dry coarse sand with trough cover having height of 112 mm and 180 mm from centre of screw by varying frequency and speed of screw and given in Table 1 and 2 respectively. The obtained results are discussed in next section.

3. Results and Analysis

Experimental results are given in Tables 1 and 2 for 112 mm high tough cover and 180 mm high tough cover respectively. From the both the tables comparison analysis has been made by considering different output responses such as mass flow rate (Q), volumetric capacity (V) and filling factor (Ψ) are: range of filling factor (Ψ) with ribbon type screw: $0.66 \leq \Psi \leq 0.72$ for 112 mm high trough cover, and $0.76 \leq \Psi \leq 0.80$ for 180 mm high trough cover and these value are also shown in Table 3. From the Table 3, it is found that increasing trend observed for all responses with increase of frequency (f) and speed of screw (n). Compared to 112 mm high tough cover, 180 mm high tough cover produced improved results in all responses. With the lower height of trough cover (112 mm) the variation of filling factor or loading efficiency with ribbon type of screw is in the range of 0.66 to 0.72 while the variation of filling factor within the range of 0.76 to 0.80 with same screw for larger height of trough cover . This is due to the fact that in case of lower height of trough cover (height 112 mm) restricts the material height over the screw top near the feeding point and thus reduces the filling factor compared to when higher trough cover is used. .

In two cases (112 mm height trough cover and 180 mm height trough cover) the filling factor or loading efficiency (Ψ) shows slightly increasing trend with speed. This may be due to variation of bulk density of load with speed. It is to be noted that normal range of speed for a 200 mm diameter is between 20 to 150 rpm. However, the experiments were carried out between 12 to 26 rpm only, because of physical limitation of manual feeding. The experiments could not be conducted at higher speeds to find out whether the filling factor (Ψ) would become constant at higher speeds.

Conclusions

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

1. The high value of filling factor is found in experimental result, due to the fact that the feeding condition is flood-feeding and length of the screw is short and without any obstruction of bearing hanger. This is quite in line with general observation that the filling factor is about 1.5 to 2 times in case of short length screw conveyors compared to that of a long one (Alexandrov, 1981).
2. 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.
3. However in both the cases: 112 mm height trough cover and 180 mm height trough cover, the filling factor or loading efficiency (Ψ) shows slightly increasing trend with frequency as well as speed.
4. This study gives clear indication increasing high tough cover value is beneficial for enhancing performance of Screw Conveyor system.

Future scope of work

i) As already mentioned earlier, there is no mechanical feeding arrangement in the newly commissioned laboratory screw conveyor. Because of this limitation, the feeding has to be done manually, which puts practical problem during experimentation. After introduction of a suitable system of automatic feeding and bringing back the delivered material to the loading end, experiments can be conducted at higher speeds and nature of variation of 'Ψ' with higher speeds can be firmly established.

ii) The effect of an intermediate bearing hanger on the filling factor could not be studied. This may be investigated in a longer screw conveyor with at least one intermediate bearing hanger.

iii) The set of experiments were done keeping the effective length of the screw constant. By shifting the position of the feeding hopper, it is possible to very it within a small range. Experiments may be conducted with different effective length of the screw to observe its effect on 'Ψ'.

iv) In present experimental set up the weighing machine is limited to weigh material up to 50 kg, which is a practical problem to perform experiment with higher speeds, as in 30 second continuous operation material conveyed is more than 50 kg. A weighing machine of higher capacity can help to reduce stages of weighing and experiment time.

References

G. Nagel, (1968), Archimedean screw pump handbook, *Prepared for Ritz- Atro Pumpwerksbau GMBH Roding,* Numberg, Germany.

A. Fuchs, H. Zangl and G. Brasseur, (2007), Mass flow meter screw conveyor based on capacitive sensing, *Proc, of IEEE Instrumentation and Measurement technology conference (IMTC*), Warsaw, Poland

Fottner and Johannes, (2000), Chacteristics of bulk material in screw type conveyors, *Engineering Meeting of Krupp, Forder Technik Session,* 28-29.

A.W. Roberts, (1999), The Influence of Granular Vortex Motion on the Volumetric Performance of Enclosed Screw Conveyors, *Powder Technology*, 104(1), 56-67.

Y. Yu and P.C. Arnold, (1996), Investigation into power requirements for screw feeders, *National Conference on Bulk Material Handling*, AUSTRALIE.

M.P. Alexandrov, (1981), Materials handling equipment,*Mir Publishers*, first edition.

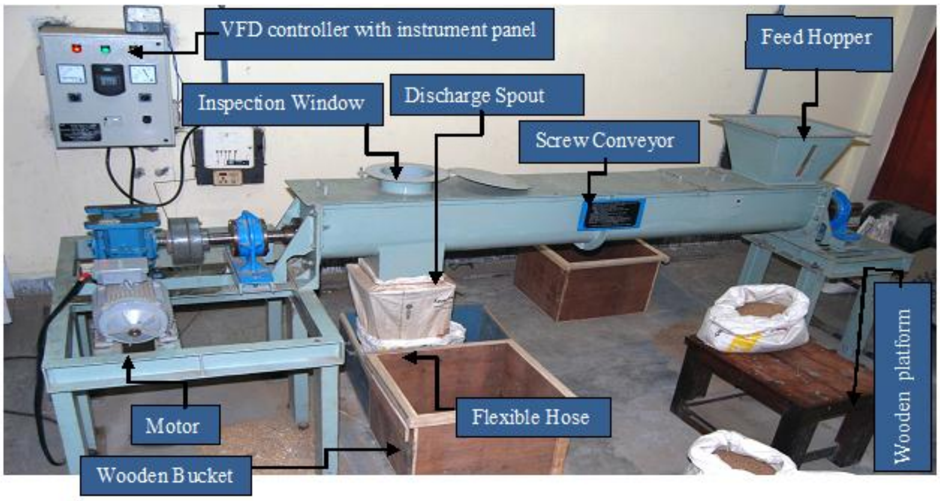

Fig.1 View of the experimental Screw Conveyor set-up.

Table 1 Experimental data sheet for trough cover having height of112 mm from centre of screw

S.N.	Frequency (f), Hz	Speed of screw (n),rpm	Operating time (t), seconds	Amount of material conveyed, kg	Average amount of material conveyed (M), kg	Mass flow rate (Q), tons/hr	Volumetric capacity (V), m^3/min	Filling factor (Ψ)
1	10	12	30	31.050	31.4	3.77	0.04	0.66
2	10	12	30	32.000				
3	10	12	30	31.150				
4	10	12	30	31.400				
5	12.5	15	30	40.620	40.073	4.81	0.05	0.68
6	12.5	15	30	39.550				
7	12.5	15	30	40.050				
8	12.5	15	30	40.072				
9	17.5	21	30	57.660	57.885	6.94	0.07	0.7
10	17.5	21	30	58.125				
11	17.5	21	30	57.870				
12	17.5	21	30	57.885				
13	21.7	26	30	75.415	74.462	8.94	0.09	0.72
14	21.7	26	30	73.940				
15	21.7	26	30	74.030				
16	21.7	26	30	74.463				

Table 2 Experimental data sheet for trough cover having height of180 mm from centre of screw

S.No.	Frequency (f), Hz	Speed of screw (n),rpm	Operating time (t), seconds	Amount of material conveyed, kg	Average amount of material conveyed (M), kg	Mass flow rate (Q), tons/hr	Volumetric capacity (V), m^3/min	Filling factor (Ψ)
1	10	12	30	36.655	36.154	4.34	0.05	0.76
2	10	12	30	34.455				
3	10	12	30	37.527				
4	10	12	30	35.980				
5	12.5	15	30	47.030	46.382	5.56	0.06	0.78
6	12.5	15	30	47.545				
7	12.5	15	30	45.695				
8	12.5	15	30	45.280				
9	17.5	21	30	65.600	66.073	7.93	0.08	0.80
10	17.5	21	30	66.670				
11	17.5	21	30	65.905				
12	17.5	21	30	66.117				
13	21.7	26	30	81.130	81.660	9.80	0.1	0.79
14	21.7	26	30	81.660				
15	21.7	26	30	81.955				
16	21.7	26	30	81.895				

Table 3 Result comparisons between 112 mm high tough cover and 180 mm high tough cover

Input parameters		Output responses					
Frequency (f) in Hz	Speed of screw (n) in rpm	Q in t/h		Volumetric capacity (V) in m^3/min		Filling factor (Ψ)	
		with 112 mm high tough cover	with 180 mm high tough cover	with 112 mm high tough cover	with 180 mm high tough cover	with 112 mm high tough cover	with 180 mm high tough cover
10	12	3.77	4.34	0.04	0.05	0.66	0.76
12.5	15	4.81	5.56	0.05	0.06	0.68	0.78
17.5	21	6.95	7.93	0.07	0.08	0.70	0.80
21.7	26	8.94	9.80	0.09	0.10	0.72	0.79