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INCREASING OF SCREW CONVEYOR CAPACITY

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ABSTRACT
Screw conveyors are used for the transmission of powder, small-grained and liquid materials in the different areas of industry. Screw conveyors have rotating helical shafts inside fixed a through or pipe. The goods are delivered with the rotation of screw. The rotational speed of screw shaft is directly related to the transmission capacity. It leads to serious balancing and vibration problems in conveyor because of the increasing rotational speed of screw shaft. The transmission capacity of materials depends on three factors. These are dimension and geometry of conveyor, characteristics of transmitted material. In this study, these parameters and change of flow rate are examined and results are given in tables.
Keywords: Screw conveyor, conveyor capacity, efficiency

1. INTRODUCTION
Screw conveyor is used helix mounted onto a rigid center shaft which is rotated axially in a fixed tube. The screw which is rotating creates a translational movement so that the bulk materials are transported by the frictional resistance. There are a number of significant theoretical and experimental studies to the screw conveyors which aim to increase the capacity. The experimental studies of the performance of screw conveyors were studied in [1-3] and screw or auger conveyor performance are also provided in [4]. The processes of grain relocation with screw conveyors were undertaken by [5] recently.

Generally, the approximate efficiency of screw conveyors is given theoretically by

$$Q = \frac{\pi}{4}.(D^2 - d^2).S.n.\rho.\psi.k \qquad (1)$$

where

- Q :the theoretical of mass efficiency ($kg \cdot s^{-1}$)
- D :screw Diameter (m)
- d :shaft Diameter (m)
- S : screw pitch (m)
- n : rotational speed (rpm)
- ρ : bulk density ($kg \cdot m^{-3}$)

- ψ : coefficient of conveyor's filling
- k : incline factor

The rotational speed depends on a natural frequency of conveyor. It needs to increase the diameter of shaft to obtain a higher natural frequency. The critical rotation speed for different diameters of shaft depending on the values natural frequencies were calculated by FEM method was given Table1. It was also given the rotational speed can be used in conveyor and the net capacity in Table1.

Table1. The critical rotational speed for different diameters of shaft

The diameter of shaft *(mm)*	The natural frequency *(Hz)*	Rotational speed *(Rpm)*	Rotational speed can be used *(Rpm)*	The net capacity of flow rate *($kg \cdot s^{-1}$)*
32	9,039	540	184	1,636
55	16,215	972	331	2,569

The conveyors which have a big radial clearance between screw and tube are used in our industry of Turkey. This is not a problem in the transmission of adhesive materials such as soda ash (Na_2CO_3). The vibration of conveyor is reduced because these materials make bearing around the tube.

The radial clearance especially for the fluent materials like a polypropylene (PP) is very important for leakage. We suggest that the calculation of leakage is used the approaches of the average viscosity for fluent materials. The leakage between screw and tube should be determined using the formula

$$Q_L = \frac{\Delta P * A^2 * \rho}{8 * \pi * \mu * L} \quad (2)$$

where

- Q_L : the leakage ($kg \cdot s^{-1}$)
- ΔP : the difference of pressure (Pa)
- A : the area of clearance (m^2)
- μ : the dynamic viscosity (Pas)
- L : the length of conveyor (m)

In this study, the average dynamic viscosity for PP fluent materials was determined by experimental methods. The net flow rates were calculated in the different incline of screw conveyor which has s specific geometry by using this viscosity. These results verified in experimental studies. Additionally, it has not been change in the dynamic behavior, when the conveyor speed has increased up to the calculated I. natural frequency of 2/3.

2. THE EXPERIMENTAL STUDY ON SCREW CONVEYOR

The experimental work on the screw conveyor has been done in this study. The screw conveyor used in experiment shows in the Figure 1. The experimental on screw conveyor is used the materials of polypropylene (PP) in this study. PP is a plastic polymer, is used in many different industries and has low viscosity materials, so that it is very difficult to transmission of high incline.

In generally, the radial clearance is important in conveyor. The radial clearance needs to be at least 1.5 times larger than the maximum particle size to prevent jamming of particles in the clearance space leading to particle attrition and increased energy loss. The clearance needs to be limited a maximum value of about 3 times of the maximum particle size to prevent excessive slip back and loss efficiency at higher angles of elevation [6].Conveyors have more clearance than the literature were used in our experiment, because most of manufacturers of conveyors in our country choose tubes that are ready in industry.

Figure1. The screw conveyor

Figure 2. Polypropylene (PP)

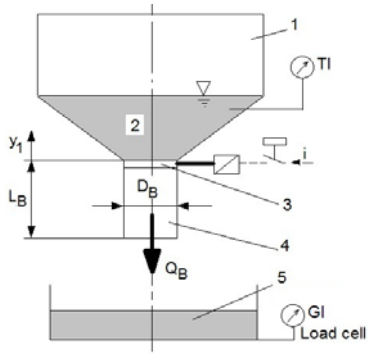
The specifications of conveyor was used in test is given in Table1. The experiments were performed for different angle.

Table 2. The specifications of conveyor

Tube diameter	125 (mm)
Screw diameter	125 (mm)
Screw pitch	125 (mm)
Shaft diameter	32 (mm)
Rotational speed of screw	184 (mm)
Length of screw	3700(mm)

2.1. The Average Dynamic Viscosity Test System

The average dynamic viscosity was found to be experimentally for fluid granules or powdered materials Figure 3. The flow is laminar in the outlet pipe of hopper. In this case, the changing of flow depending on pressure can be considered linear.



1. Hopper
2. Granule PP
3. Selenoid valve
4. Pipe
5. Load cell

Figure 3. The test equipment of dynamic viscosity

The average dyanmic viscosity is calculated in (4)

$$Q_B = \frac{1}{2}.\int_0^h \frac{\pi.\rho.g.D_B^4}{128.\mu.L_B}dy \quad (3)$$

$$\mu = \frac{\pi * \rho * g * h_B D_B^4}{128 * L_B * Q_B} \quad (4)$$

where

- Q_B : measured flow rate ($kg \cdot s^{-1}$)
- h_B : the height of materials in hopper (mm)
- g : gravitational acceleration ($m.s^{-2}$)

3. THE EXPERIMENTAL STUDY RESULTS

Firstly, the experimental flow rates were obtained from the three different inclination of conveyor. The experimental and the leakage flow rates are given in the Table 3.

Table 3. The flow rates of conveyor

The angle of conveyor (^{0})	The experimental flow rate Q_{ex} ($kg.s^{-1}$)	The leakage flow rate Q_L ($kg.s^{-1}$)	The net capacity flow rate Q_n ($kg.s^{-1}$)	Q_L / Q_n (%)
30^0	1,3677	0,2866	1,636	17,3
45^0	1,175	0,4052	1,6543	28,6
60^0	0,7938	0,4963	1,5802	38,46

Incline factor (k) is calculated using the Table 3 and result are given in the Table4.

Table 4. The incline factor (k)

The angle of conveyor	k
30^0	0,753
45^0	0,719
60^0	0,537

4. CONCLUSION

The transmission materials of granule PP which has non–adhesive are fluent materials at room temperature. It was determined by the experiment studies that the leakage flow rates were very high value for fluent materials in conveyors which have a big clearance. Additionally, the incline factor should be ascertained experimentally depending on materials. The second factor effect on the capacity is the speed of conveyor. This value depends on the natural frequency of conveyor. (It is 14%in our example). In this case it is possible to increase the speed of transmission. The flow rate significant increases when the speed of transmission increases. (It is approximately 64% in our example).

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