Design of feed screw conveyor

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Abstract. Aiming at the problem of material transportation in the feed industry, a kind of feed screw conveyor was designed. The overall structure design of the screw conveyor was completed according to the parameters of material particle characteristics and conveying requirements of the feed. The functional parameters in the design process of the screw conveyor were calculated. The test results show that the design meets the transportation requirements and provides a reference for similar material transportation.

1. Introduction
With the rapid development of the animal husbandry industry, its demand for feed is increasing. And the problem of material transportation in the feed production process has become urgent for the feed industry. General feed conveying equipment is divided into two types[1]: conveyor belt and screw conveyor. Screw conveyor is mechanical equipment which makes use of the rotating motion of screw to continuously transport materials forward. Besides realizing horizontal, inclined and vertical transportation, it also has the advantages of strong adaptability, simple structure, convenient installation and use, and is widely used in grain, feed, chemical industry, cement, food, etc. However, the structure of the screw conveyor is very different. There are many design parameters, the characteristics of the materials conveyed in different industries are different, and the requirements for transportation and installation are very different. Especially for some key parameters, improper selection and combination will seriously affect the efficiency and performance of screw conveyor. The purpose of this paper is to design a kind of screw conveyor for feed particle characteristics and conveying requirements, which can save labor cost, improve feed conveying speed and serve feed production industry.

2. Structure design and principle of feed screw conveyor

2.1. Overall structure design of feed screw conveyor
The overall structure of feed screw conveyor is composed of conveyor head, feed inlet assembly, screw body assembly, conveying section assembly and discharge outlet tail. As shown in Figure 1, rubber gasket is used to seal the components when they are connected to ensure the sealing performance of the equipment.
2. Structural component design

2.2. Conveyor head

The conveyor head provides the power and speed required for conveying materials for the whole screw conveyor equipment, which is composed of the reduction motor, chain drive, support frame and other parts. Considering the demand of speed ratio transformation, uneven load in the process of buffered feed conveying, on-site installation and other factors, the conveyor head structure of this design adopts the side mounted form of chain type reducer motor, and the structural form is shown in Figure 2. The reducer motor in the conveyor head provides power for the power unit. The chain drive changes the direction of motion and changes the speed of the screw shaft. The support frame body is the frame support body, on which the reducer motor and the support frame are installed.

2.2.2. Feed inlet assembly and conveying section assembly

The feed inlet assembly is used to receive the materials transferred from the previous process. In this design, the large feed inlet structure scheme is adopted. The wide feed inlet is conducive to the smooth collection of materials in the silo into the conveyor, so as to prevent the problem of blocking due to the slow feeding speed. The feed inlet assembly is made of 3.0mm carbon steel plate bent and welded, and the structure is shown in Figure 3.

The conveying section assembly provides the cavity for conveying materials. Considering the particle characteristics of feed, conveying dust, installation and maintenance, and other factors, the conveying section components adopt the tubular section machine slot, the inner surface is smooth and flat without bulge or dead angle of accumulated materials, the circular discharge port, the upper part is...
provided with a shaped maintenance cover door, which is sealed by the maintenance cover plate, which is convenient for cleaning and maintenance. The cylinder structure is made of 3.0mm carbon steel by crimp welding, and the structure is shown in Figure 4.

2.2.3. Screw body assembly
As the key part of the screw conveyor, the screw body assembly is mainly composed of the rotating shaft and the screw blade. Considering the factors such as the large amount of feed produced and transported, the grain material characteristics of feed and so on, the solid spiral blade was adopted, the blades are rotated to the right. The spiral blade is cut with 3.0 mm thick carbon steel plate to form a ring with notch, then the ring is drawn into spiral blade and welded on the rotating shaft. The structural design of the spiral component is shown in Figure 5.

2.2.4. Discharge outlet tail
The discharge outlet tail is composed of two parts: the discharge shell and the tail. The conveyed feed particles are discharged through dead weight from the lower part of the discharging shell. The tail is used to support the screw assembly. The discharging shell structure is shown in Figure 6, and the tail structure is shown in Figure 7.

2.3. Working principle of screw conveyor
Feed enters the equipment from the feed inlet in the previous production process. The output power of the conveying head drives the screw assembly to rotate. Driven by the rotating blade of the screw assembly and under the action of its own gravity and the friction of the conveyor trough, the feed particles move forward along the shaft in the form of compound motion and rotation, and finally discharge the material from the outlet, so as to realize the distance transportation of the material.
3. Design and calculation of feed screw conveyor

3.1. Design input parameter

Table 1. Design input parameters of screw conveyor

| Material | Conveying capacity Q (T/h) | Conveying length L (m) | Filling coefficient ψ | Inclination coefficient C | Particle diameter (mm) |
|----------|-----------------------------|------------------------|----------------------|--------------------------|-----------------------|
| Pellet feed | 15                          | 10                     | 0.3                  | 1                        | 4                     |

3.2. Calculation of diameter and pitch of spiral blade

For the screw conveyor, the conveying capacity is:

\[ Q = 3600F \rho V C \]  \hspace{1cm} (1)

In the formulas: \( Q \) is the conveying capacity of the screw conveyor (T/h), \( F \) is the cross-sectional area of the feed layer in the tank (m²), \( V \) is the axial movement speed of the feed in the tank (m/s), and \( \rho \) is the feed density (T/m³), \( C \) is the coefficient of inclination. In this design, the screw conveyor is installed horizontally, taking \( C = 1 [2] \).

\[ F = \varphi \pi D^2/4 \]  \hspace{1cm} (2)

In the formulas: \( \varphi \) is the filling coefficient, \( D \) is the diameter of the rotating blade on the rotating body assembly.

The feed is a granular material with good fluidity, and the influence of the feed screw axial block is usually not considered. Therefore, the axial moving speed of the feed in the machine feed tank is:

\[ V = S \pi n/60 \]  \hspace{1cm} (3)

In the formulas: \( S \) is the pitch of the screw blade (m), \( n \) is the rotation speed of the screw assembly shaft (m/s).

From the formula (1), (2), (3):

\[ Q = 47D^2 S n \varphi \rho C \]  \hspace{1cm} (4)

From the formula (4) and the design input parameters provided in Table 1, the unknown design parameters need to be completed are: \( D \) screw blade diameter, \( s \) is the pitch of the screw blade, \( n \) is the rotation speed of the screw assembly shaft.

The design and calculation formula of screw blade diameter is as follows:

\[ D = K^{0.5} \sqrt[3]{Q/\varphi \rho C} \]  \hspace{1cm} (5)

In the formulas: \( K \) is the comprehensive characteristic coefficient of materials[3], which can be consulted from reference 3. For granular grains, \( K = 0.049 \), and the rest parameters have the same meaning as above. Calculated by formula (5), \( D = 0.262 \)m

The calculated screw blade diameter \( D \) shall be rounded to the following standard pitch diameter[4]: 150 mm, 200 mm, 250 mm, 300 mm, 400 mm, 500 mm, 600 mm. In this design, the rounded screw blade diameter is 250mm.

The pitch of the screw blade not only determines the rising angle of the screw, but also determines the sliding surface of the material under a certain filling coefficient, so the pitch directly affects the conveying process of the material. Generally, for solid blade, \( S = 0.8D \), so the pitch of screw blade \( S = 200 \)mm. The structural parameters of the diameter and pitch of the screw blade are shown in Figure 8.
3.3. **Calculation of screw shaft speed**

The rotation speed of the screw shaft has a great influence on the conveying volume. Generally, the higher the rotation speed is, the greater the conveying volume is, and vice versa[5]. If the speed exceeds a certain limit, the material will be thrown along the tangential direction due to centrifugal force, unable to promote the material.

\[
 n \leq n_j = A/\sqrt{D} \tag{6}
\]

In the formulas: \( n_j \) is the limit speed of screw shaft (r/min), \( A \) is the comprehensive coefficient of material. Refer to reference 3, \( A \) value is 50, and the meaning of other parameters is the same as above.

\[
 n \leq n_j = A/\sqrt{D} = 100 \text{ (r/min)}
\]

3.4. **Drive power calculation and motor selection**

The driving power of the screw conveyor is the energy consumed to overcome various resistances in the material conveying process. Power of screw shaft[6]:

\[
 P_o = \frac{Q(\mu_0 L + H)}{367} \tag{7}
\]

In the formulas: \( P_0 \) is the required power of the screw shaft (Kw), \( \mu_0 \) is the material resistance coefficient, refer to Reference 3, the feed \( \mu_0 \) is 2.5, \( L_h \) is the horizontal projection of the working length of the screw(m), \( H \) is the vertical projection length of spiral working length (m), the other parameters have the same meanings as above.

\[
 P_o = \frac{Q(2.5 L + H)}{367} = 1.02 \text{Kw}
\]

Drive motor power:

\[
 P_s = k \frac{P_o}{\eta} \tag{8}
\]

In the formulas: \( P_s \) is the driving power of the motor (Kw), \( k \) is the power reserve coefficient (\( k = 1.2-1.4 \), \( \eta \) is the total transmission efficiency of the driving device, average value of 0.9 to 0.94[7].

\[
 P_s = k \frac{1.02}{0.9} = 1.41 \text{Kw}
\]

According to the above calculation, it is known that the motor power is 1.41Kw and the rotation speed is 100r / min. The model of the decelerating motor is selected as cycloida pin gear speed reducer and the model is: BWD11-11-1.5.

4. **Conclusion**

This paper studies and designs a kind of feed screw conveyor, completing the design of the overall structure and each structural part of the screw conveyor. Combined with the parameter requirements of feed particle characteristics and conveying requirements, it expounds the selection and calculation of the key performance parameters such as the diameter and pitch of the screw blade, the rotating speed of the screw shaft, and the driving power. The field test shows that the screw conveyor designed by...
this method can effectively solve the problem of feed particle transportation, save labor cost, and provide application reference for similar material transportation.

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