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Parameter Simulation and Analysis of Rotary Feeder

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Abstract. As a kind of continuous conveying equipment for powder and pellets, rotary feeder is widely used in the processing of non-staple food products, chemical industry production, metal smelting, wine brewing and terminal transportation because of its convenient control, high reliability and stable transportation. Such industries have an important position in the bulk material conveying industry. Different process parameters and structural parameters of the rotary feeder will have an impact on the conveying effect. The process parameters affecting the conveying effect mainly include rotor speed and material filling coefficient. In this paper, the dismantling rotary feeder with the rotor diameter of Φ62 is studied by simulation and test, and the influence of rotor speed and material filling coefficient on the conveying effect is analyzed.

1. Introduction
At this stage, the rotary feeder has become a commonly used feeder in material conveying systems, and its use is widespread and popular. With the development of science and technology and the needs of industrial production, rotating machinery is constantly developing in the direction of large-scale, complicated, integrated, and high-speed. At present, for the continuous transportation machinery, the optimization research and design results for the rotary feeder in the material conveying system are relatively small, so it is necessary to carry out research work in this area to solve practical problems for the project.

2. Establishment of a rotary feeder model
The structure of the rotary feeder is relatively complicated, and the rotary feeder needs to be simplified, and unnecessary structures such as motors and bearings are omitted, so that the calculation speed is accelerated, and the simulation results are more clear and targeted.

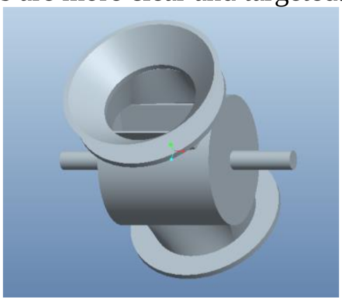


Fig. 1 Simplified model of rotary feeder

As shown in Figure 1, a simplified rotary feeder model is built in Proe to scale the model of the rotary feeder to a certain scale.

The size of the model, the accuracy of the mesh being divided, and the computational power of the computer all have an important impact on the simulation experiment. Therefore, in the modeling, we take the rotor shaft with a diameter of 10 mm, a blade diameter of 62 mm, and a blade width of 60 mm. The number of blades is 9 and distributed on the rotor shaft, and the model is introduced into the EDEM.

3. Simulation and results analysis

3.1. The effect of speed on the amount of discharge

The main problem to be studied in this subject is the effect of the rotor speed of the feeder and the filling rate of the conveying material on the conveying effect of the rotary feeder. In this experiment, four particles with a rotation speed of 20r/min are selected for analysis. Four simulated particles were randomly selected from all simulated particles, and four particles were marked and their motion trajectories were tracked. For rotary vane feeders, the user typically selects the appropriate feeder specifications by calculating the feed capacity of the feeder. Formula (2-1) is the conveying capacity of the rotary vane feeder:

$$Q = 60\rho\beta V_0 KN \tag{1}$$

In the formula:

Q——The conveying capacity of the rotary vane feeder, T/h;

Ｐ——The actual pouring density entering the feeder, kg/m3;

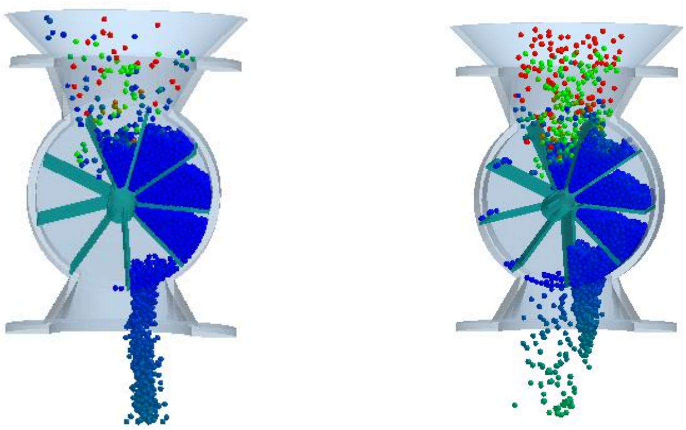
η——Filler coefficient of the feeder;

K——The number of upper wheel chambers of the rotor;

n——Rotor’s speed, r/min;

V_n——The volume of a single wheel chamber, m3.

In the actual production application, the rotor speed of the feeder plays a vital role in the control of the material conveying volume during the conveying process. Under normal circumstances, the larger the rotor speed, the larger the material conveying amount, but when the speed is too high, The blade particles of the discharge port have not yet fallen, and the particles follow the blade to return to the feed port, and the discharge is not realized, so there is a maximum rotation speed. When the rotation speed exceeds the rotation speed, the material conveyance amount decreases. In this experiment, quantitative analysis of the discharge amount was carried out by observing the discharge amount under different rotor speeds.



(a) (b)

Fig. 2 Particle motion diagram

According to past experience and existing data, the feed rate of the rotary valve feeder is generally controlled at 15 ~ 30r / min, so in this simulation scheme, the rotor speed is set to 15, 20, 25, 30, 35r / Min. Record the mass of the material passing through the unit box every 0.2s, and export the data to draw the blanking diagram under the rotor speed, as shown in Figure 3. The figure is the data derived from the initial time 0 seconds when the rotation speed is 15r/min. Since 0~2 seconds is the time when the material starts to fall, the material has not reached the position of the discharge port at this time, and the drop of the material is unstable. . Therefore, in the next analysis, only the stable blanking section (the blanking amount after 2 s) will be analyzed to observe the law of the blanking amount.

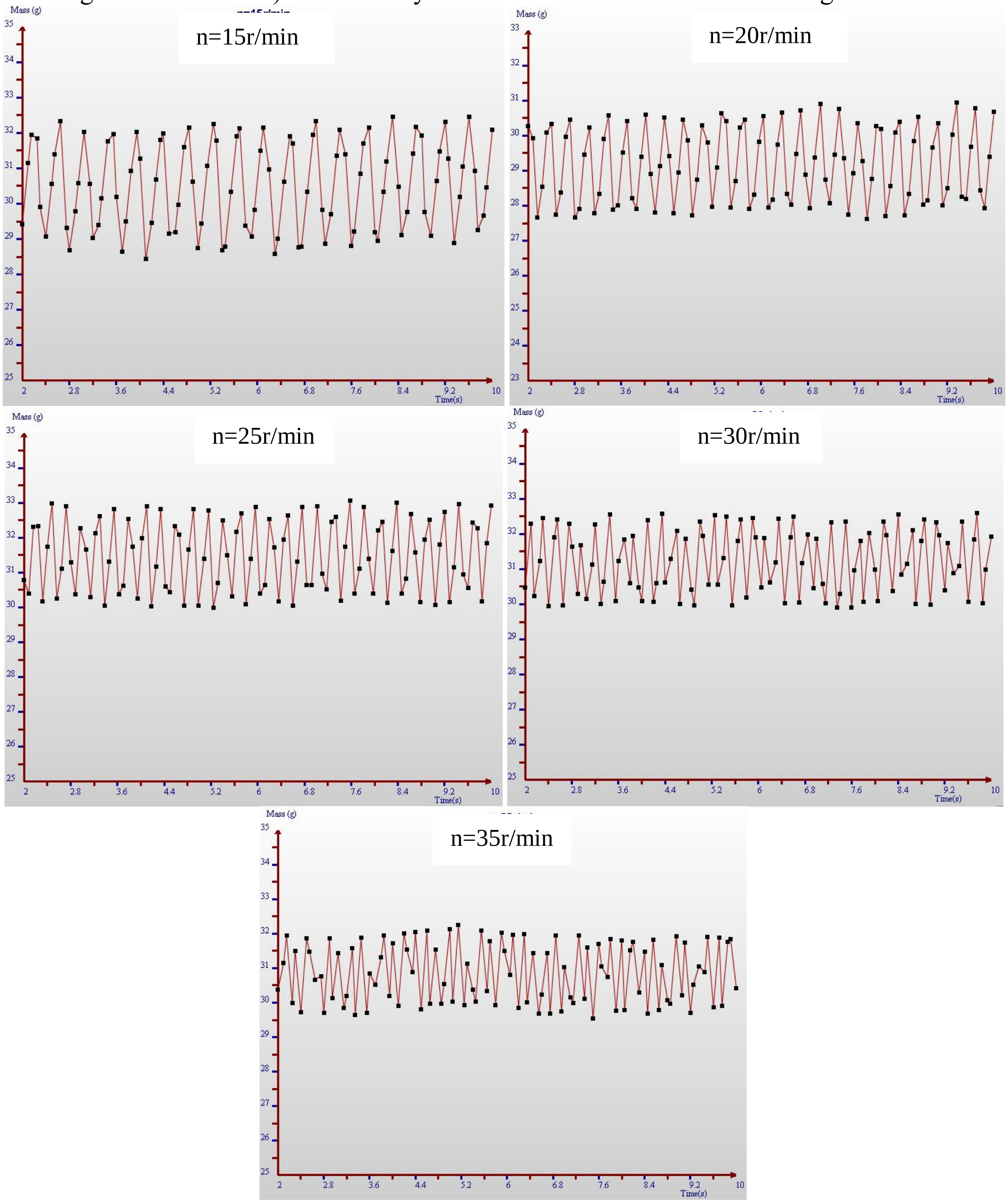


Fig. 3 Rotary feeder blanking diagram

Figure 3 shows the blank feeder blanking diagram. The vertical coordinate is the blanking mass and the abscissa is the time. From the figure, we can see that the feeding amount of the feeder changes with the speed. The mass of the output material of the feeder is periodically changed with time. This phenomenon is the pulsation phenomenon. The pulsation phenomenon occurring during the conveying process is directly related to the rotation speed of the rotary feeder rotor. The faster the rotation speed of the rotor, the shorter the pulsation cycle. Now we will get the blanking amount obtained under different rotor speeds. The maximum, minimum, amplitude, and rotation periods are averaged and organized as shown in Table 3-1 below.

Tab. 1 The variation of the quality with the rotational speed

n (r/min)	Max (g)	Min (g)	Amplitude (g)	Cycle (s)
15	32.457	29.716	2.74	0.42
20	32.573	29.832	2.94	0.31
25	32.893	29.909	2.98	0.28
30	32.593	29.906	2.69	0.21
35	32.252	29.550	2.70	0.18

From Table 1, we can see that as the rotor speed increases, when the rotor speed is 15~25r/min, the maximum and minimum values of the blanking amount increase with the increase of the rotor speed. Maximize at 25r/min. Now the maximum and minimum values of the blanking amount are plotted, as shown in Figure 4. It can be found through observation that the change of the blanking amount in a certain speed range is basically linear, when the rotor speed is 15~25r/ At min, the maximum and minimum values of the blanking amount increase with the increase of the rotational speed. However, when the rotor speed reaches 30r/min and 35r/min, the maximum and minimum values of the blanking amount are reduced. This is because when the rotor speed is too large, the material will be brought back completely if it fails to fall. As shown in 3-11(b), it can be clearly seen that some of the particles have not fallen, indicating that there is an optimum speed, and the optimum speed of 25 r/min is very difficult to approach the actual application speed, which is significantly lower than the theoretically calculated optimum speed. It shows that the simulation method is indeed more reliable than the theoretical calculation. At the same time, the numerical simulation is very intuitive to reflect the pulsation of the rotary feeder feeding capacity.

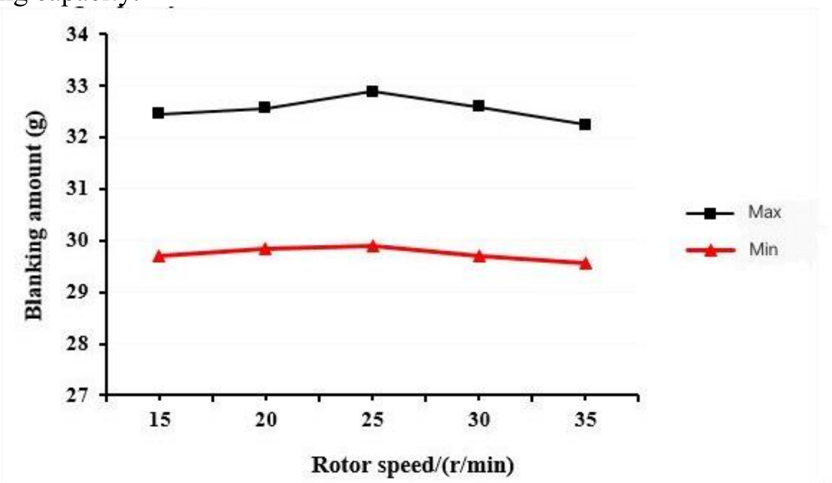


Fig. 4 Blanking amount atdiffrent rotation rate

It is known that the calculation formula of the rotation period of the rotary feeder rotor is:

$$T = \frac{2\pi}{w} \tag{2}$$

According to the formula, when the rotor speed is 15, 20, 25, 30, 35r/min, the rotation time of the blade is 3.93s, 2.99s, 2.42s, 2.01s. In the experiment, the rotor has a total of 9 blades. It can be seen that the rotation period of each blade is 0.44s, 0.33s, 0.27s, 0.22s, which is consistent with the rotation period in the simulation experiment, so that the experimental rotor rotation period can be consistent with the theoretical value.

It can be seen from the analysis of Fig. 4 that in the material transportation process of one cycle, the material flow rate conveyed in each wheel chamber is not completely consistent, and there is unevenness. The relatively large influence on the whole feeding process is the rotation speed of the rotor. It can be known that in order to control the amount of material to be conveyed during the material conveying process, the first thing to consider is the rotor speed of the feeder. Through this simulation experiment, when the rotor speed is about 25r/min, the blanking amount reaches the maximum value, that is, the conveying efficiency is the highest when the rotor speed is about 25r/min.

3.2. The effect of speed on mass flow rate

The mass flow rate of the medium is a parameter that quantifies the flow pattern of the particles in the feeder by speed. The measurement of this parameter is performed by selecting a plane parallel to the rotor axis and recording the number of all particles flowing through the plane. In this simulation experiment, a plane parallel to the exit is selected as the detection plane of the mass flow rate.

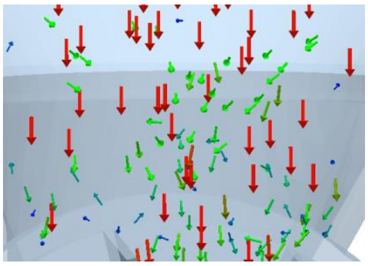
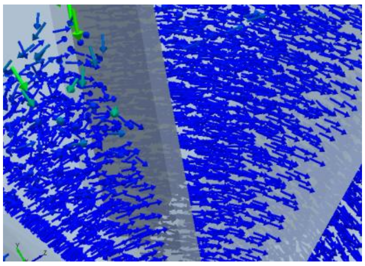
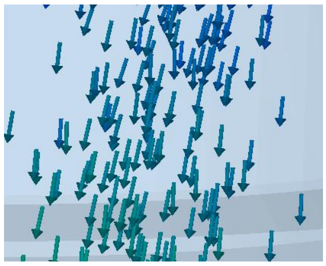




Fig. 5 Feeding mouth speed vector **Fig.6** Wheel indoor speed vector **Fig. 7** Outlet speed vector

Figure 5 shows the speed vector at the feed port. The difference in particle velocity at the feed port is due to the fact that the particles are not simply free-falling movements before entering the feeder inlet. The actual situation is that the particles have different initial velocities when feeding the material. It can be seen from Figure 6 that after the particles enter the feeder wheel chamber, the initial kinetic energy is partially offset by the rotor force, the speed is reduced, and the particle velocity entering the rotor wheel chamber varies with the rotor speed. . It can be seen from Fig. 7 that the material of the discharge port gradually becomes larger due to the rotation of the rotor and the action of gravity.

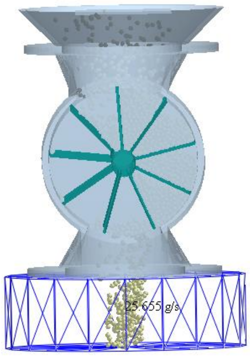


Fig. 8 Mass flow rate chart

Figure 8 shows the mass flow rate detection diagram. Select a plane parallel to the rotor axis at the material exit, establish a mass flow velocity sensing cell grid, perform real-time detection of the mass flow rate, and extract the mass flow rate to average and analyze the difference. Fill factor and mass flow rate at different speeds.

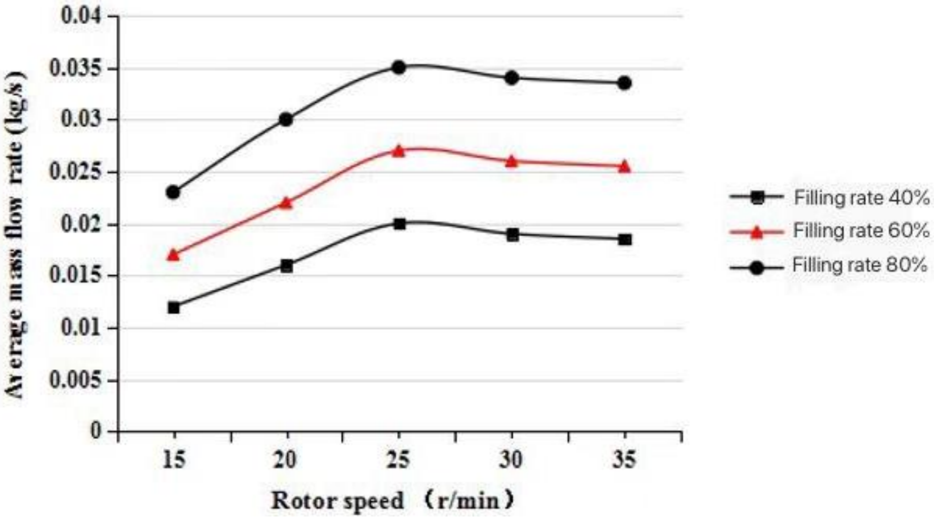


Fig. 9 Relationship between rotor speed and mass flow rate

Figure 9 shows the mass flow rate at different rotor speeds. When the material fill factor is set to 40%, the rotor speed is 15r/min, 20r/min, 25r/min, 30r/min, 35r/min. The average mass flow rates were 0.012 kg/s, 0.016 kg/s, 0.020 kg/s, 0.023 kg/s, and 0.025 kg/s, respectively. When the material filling factor is set to 45% and the rotor speed is 15r/min, 20r/min, 25r/min, 30r/min, 35r/min, the average mass flow rate of the material is 0.017kg/s, 0.022kg/s. , 0.027 kg / s, 0.031 kg / s, 0.034 kg / s. When the material filling factor is set to 60% and the rotation speed is 15r/min, 20r/min, 25r/min, 30r/min, 35r/min, the average mass flow rate of the materials is 0.023kg/s and 0.030kg/s, respectively. 0.035 kg/s, 0.040 kg/s, 0.043 kg/s. When the filling factor of the material is increased from 40% to 80%, the mass flow rate of the material at different rotor speeds increases by 1.92 times, 1.88 times, 1.75 times, 1.73 times, and 1.72 times, respectively. It can be seen from the data that when the filling factor of the material is doubled, the increase in the mass flow rate of the material is not doubled. At the same time, as the rotational speed of the rotor increases, the increase in the mass flow rate of the material is decreasing. Analysis of Figure 4-16 shows that under the same material fill factor, the mass flow rate increases with the increase of the rotor speed, and the material mass flow rate value is basically linearly related. In addition, it can be found that at the same rotor speed, the filling factor of the material increases, and the average mass flow rate of the material also increases correspondingly, and when the rotational speed of the rotor increases, in the case of different material filling factors of the same rotor speed, The magnitude of the increase in the average mass flow rate of the material has increased. In addition, it can be found that under the same material filling factor, the increase in the mass flow rate of the material is reduced after the rotor speed is increased to 30 r/min. Through simulation analysis, it is found that if the mass flow rate of the material is to be changed simply by changing the filling factor and cannot be quantitatively changed by the material filling coefficient, the material mass flow rate can be adjusted by the combination of the rotor speed and the filling coefficient.

4. Conclusion

Five rotor speeds and three material fill factors were set in the experiment, and 15 sets of simulation experiments were carried out. Through 15 sets of simulation experiments, the data such as material drop amount and average mass flow rate during the transportation process were obtained, and the optimal value of material transportation was obtained by analyzing the data, and the empirical parameter values selected in the previous transportation were optimized. Through experiments, it is found that to achieve the same mass flow rate, the filling factor required for different speeds is also different, the filling factor is reduced, and the rotor speed to be set should be increased accordingly. Through simulation experiments, the transmission efficiency is highest when the rotor speed is about 25r/min. When the rotor speed is higher than 30r/min, the power consumption will increase significantly. Therefore, the rotor speed should not exceed 30r/min; the filling factor of the material is improved. The smaller the moving speed of the material inside the feeder, the larger the filling factor can be selected as much as possible under the premise of the conveying conditions.

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