Kinematics Research on Small Feed Mill*

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***Abstract*—Crushing is one of the important processes in feed processing. Through crushing, the total surface area of raw material particles per unit mass can be increased, the solubility of feed nutrients in animal digestive juices can be increased, and the digestibility of animals can be improved; At the same time, the particle size of the crushed raw materials has a very important impact on the difficulty of the subsequent process and the quality of the finished product. The crushing effect affects the feed processing cost and processing quality, and the hammer mill is one of the important equipment for feed crushing. In this paper, Recurdyn is used to study the kinematics of the small hammer mill under working conditions. Research has shown that the system uses high-speed rotating hammers to crush the material, and once again pass through the screen to achieve a crushing effect. The structure is simple, the versatility is strong, and the production efficiency is high. It provides a theoretical basis for the majority of users to use the shredder safely with high efficiency, high quality and low consumption.**

Keywords—Feed processing; grinder; kinematics ;

I. INTRODUCTION

The feed industry is in a new stage of development in our country, and the development level of the feed industry has become an important indicator of the development of modern agriculture[1,2]. There are many ways to crush feed, such as: chopped, ground, crushed, etc. In production, the crushing model mainly depends on the characteristics of the material being crushed. Generally speaking, the granular feed is mostly crushed by crushing methods. The main models are hammer type, tooth claw type, hammer type, and counter-roll type, etc[3,4]. Hammer type crusher has the advantages of no load can be quickly started, crushed material quality is better, maintenance is more convenient[5,6]. In production, the existing shortcomings of hammer mills mainly include high crushing energy consumption, low screening efficiency, high noise, materials that have been crushed, rapid feed temperature rise, and severe wear of hammers and screens. At present, many small and medium-sized feed mills in our country still use traditional horizontal hammer type feed mills[5,7]. The model is shown in Fig.1. When the material enters the crushing cavity, the material particles are crushed under the action of the high-speed rotating hammer and the frictional impact of the wall tooth plate, and the material particles that meet the screen are discharged through the screen. The disadvantage of the traditional horizontal hammer mill is that there is a material circulation layer in the crushing chamber, that is, the large particles in the crushing chamber are distributed on the outer layer under the action of centrifugal force, which hinders the penetration of particles that meet the screening size; in addition, there is a negative pressure in the center of the crushing chamber, which has a certain adsorption effect on small particles. As a result, some materials that meet the particle size requirements cannot be discharged in time, causing repeated crushing of the materials, resulting in the screening efficiency of the crusher being lower than the crushing efficiency[8, 9].

II. MODEL AND WORKING PRINCIPLE

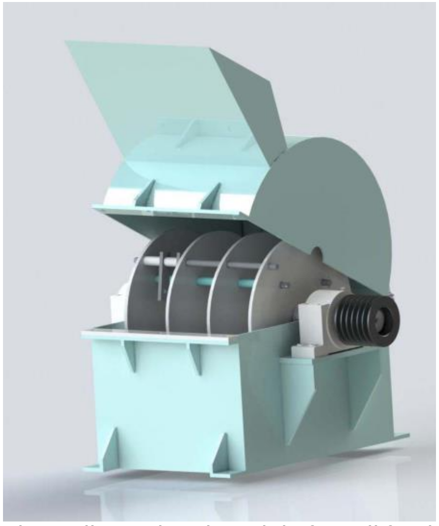


Fig. 1. *Three-dimensional model of small feed grinder*

The crusher is composed of six parts: upper body, lower body, rotor assembly, screen, feeding device, and frame. The machine body and the rotor assembly form a crushing chamber. The rotor assembly is the main working part. The crushing of materials is completed in the crushing chamber. Dry materials can be crushed into powder with high efficiency and speed. The materials are crushed by high-speed rotating hammers and passed through the sieve. The net is broken into a crushing effect. The model has a simple structure, strong versatility and high production efficiency. This feed grinder is 70cm in length, 75cm in width and 74cm in height. The spindle speed of 3880 is full of power and the weight of the whole machine is 80kg. The supporting power is a three-phase, 5.5-kilowatt national standard motor. The output can reach 900 kilograms per hour. The screen hole is directly 3mm. It can be used for crushing grain materials such as corn, beans, grains and wheat. It can also be used for sweet potatoes. The cutting and crushing of lumps such as potato and dry straw, grass and other crude fibers have a wide application range and high work efficiency. It can better increase the feed surface and adjust the particle size, increase the surface area, improve the palatability of livestock and poultry, and improve the digestibility. Can better absorb the nutrients of feed. The crushed material enters from the feed port of the crusher by gravity. Its falling speed is generally 0.15m/s ～ 0.30m/s. Then it comes into contact with the end of the hammer whose linear velocity is above 80m/s. After the low-speed material hits the high-speed hammer violently for the first time. Pulled into the acceleration zone by the hammer, the particle velocity can be increased to close to the end linear velocity of the hammer in a short time. And make a circular motion with the hammer. In the full speed zone, a material circulation layer is gradually formed. At the same time, the material is further crushed. Since then, the hammer will hit the material to the sieve plate at a very high speed. But the material itself moves in a direction perpendicular to the direction of the hammer. Therefore, it is difficult for the material to pass through the sieve holes.

III. BUILD MODEL

The box of the crusher is a complex frame structure welded by plate and section steel, which bears the vibration force generated by the spindle speed drive of 3880, the impact load of the system and the uneven load of the material, and the stress state of the box structure is complex. In this paper, a kinematics simulation is carried out for a small feed grinder.

A. *Geometric model establishment*

Firstly, a 3D model of a small feed grinder was established in the 3D modeling software, as shown in Figure 1. Secondly, import the established 3D model into Recurdyn through the .x_t file. Before analysis, the model needs to be pre-processed. The specific modeling process is as follows: According to the analysis requirements, directly delete the box, inlet, bolt and other structures that are not related to the analysis. After the deletion, the model is further simplified. The material selected for the frame of the small feed grinder, the feeding device, etc. is structural steel. The elastic modulus of the structural steel is E=2e11pa, Poisson's ratio is μ =0.3, the density is ρ =7850kg/m^3. The total weight of the system is 505.52kg.

B. *Restraint and load*

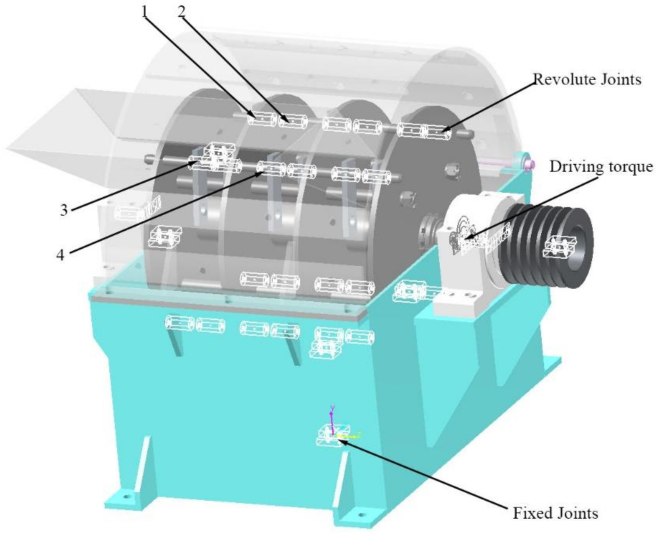


Fig. 2. *Restraint and load*

The frame and the ground, the bearing seat and the frame are constrained by a fixed pair, the screen and the rotor assembly, and the rotor assembly and the bearing seat are connected by a rotating pair, as shown in Fig. 2. Set the frame and A driving pair is set between the bearing seats. Because of the 3880r/min driving motor used in the small feed grinder, the speed of the driving pair is 406.31rad/s, as shown in Fig.3.

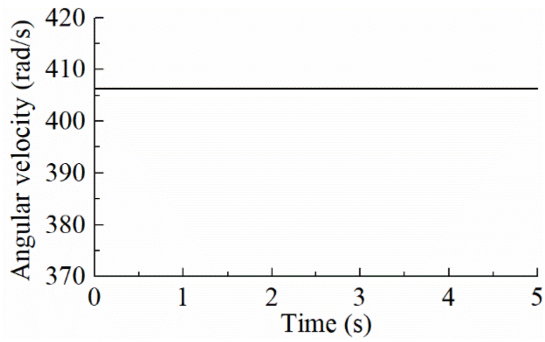


Fig. 3. *Angular velocity*

IV. SIMULATION RESULT

The kinematics simulation results of the small feed grinder are shown in Figure 4-9. From the simulation results, it can be seen that the driving torque of the system is 8.5×10^6 N.mm when the system provides power at the spindle speed of 3880, as shown in Fig.4. At this time, the hammer achieves high-speed rotation through the driving torque, so as to crush the material and pass through the screen into a crushing effect. Among them, the coaxial rotating pair 1 and the rotating pair 2, and the rotating pair 3 and the rotating pair are shown in Figure 2. The torque of 4 is shown in Fig. 5 and Fig. 6, respectively. It is not difficult to see that due to the different positions of the screens, their torques are different during the system startup and stable operation. But in the process of stable operation, the driving torque of each screen is periodically stabilized at 1.41×10^5 N.mm. In addition, Figures 7-9 show the displacement of a point on the frame, the rotor assembly, and the screen respectively. Since the rack is directly installed on the bottom surface, the point on the rack is constant on the xoy during the stable operation of the system, as shown in Figure 7. In addition, since the system is driven by a drive motor of 3880r/min, the points on the vibrating system screen and the rotor system are in periodic motion, as shown in Figure 10 and Figure 9, respectively.

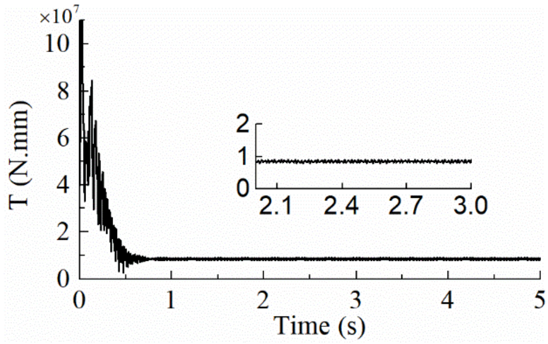
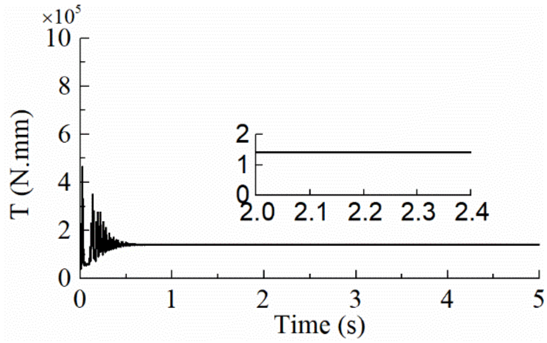


Fig. 4. *Driving torque*



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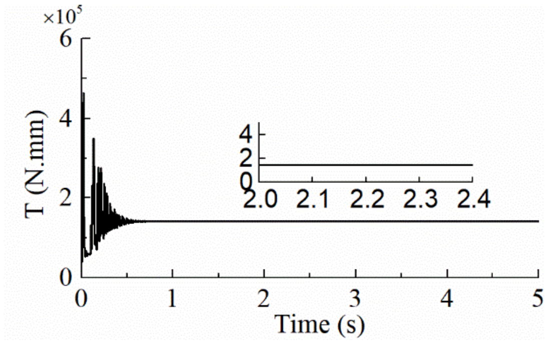

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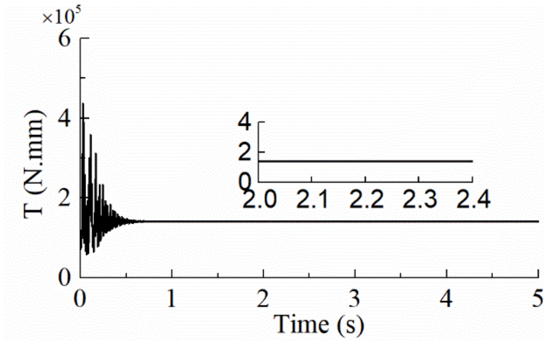
Fig. 5. *Torque of rotating pair 1 and rotating pair 2*



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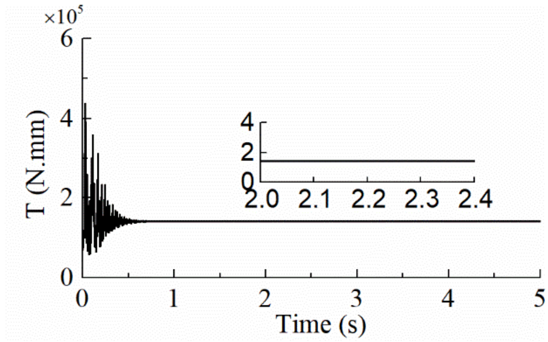

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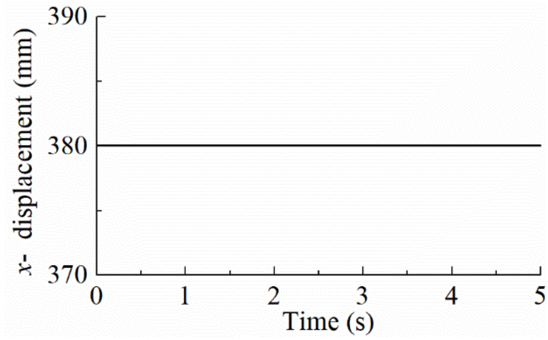
Fig. 6. *Torque of rotating pair 3 and rotating pair 4*



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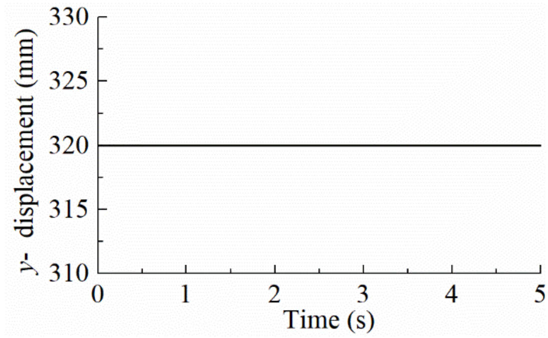
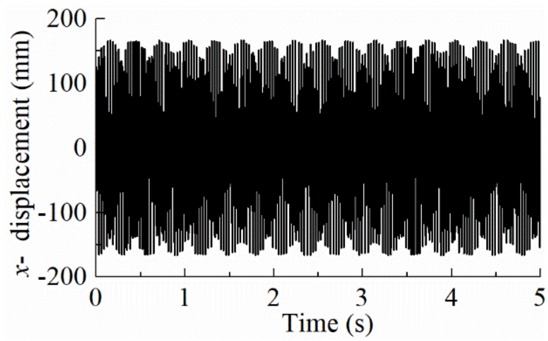


(b)

Fig. 7. *The displacement of the frame at a certain point*



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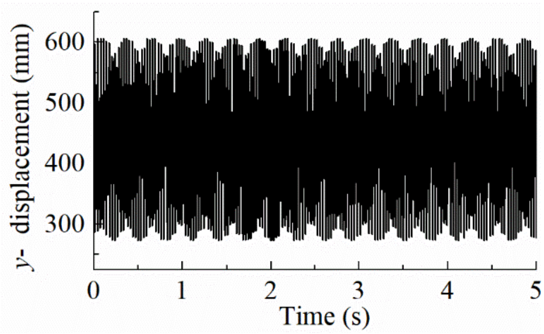

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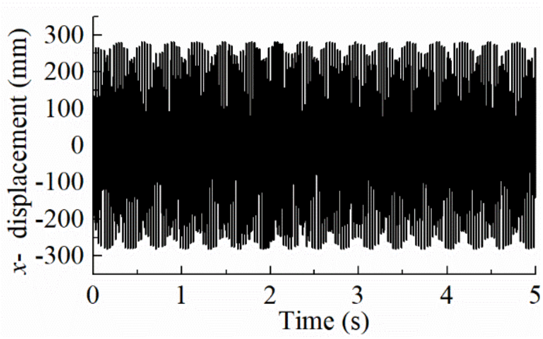
Fig. 8. *Displacement of a point on the rotor assembly*



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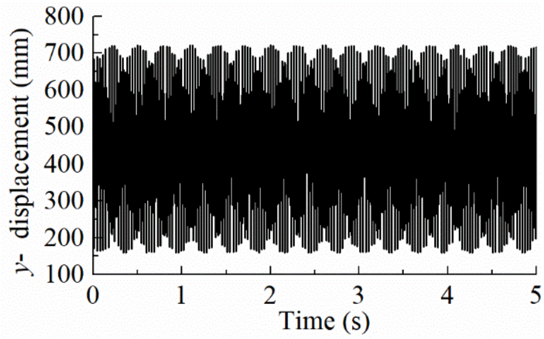

(b)

Fig. 9. *The displacement of the center of mass of a sieve plate*

V. CONCLUSION

In this paper, a three-dimensional model of a small feed grinder is established, and a rigid body kinematics model is established in Recurdyn, and the dynamic simulation is carried out. The main conclusions are as follows: The system is driven by the spindle speed of 3880 to realize the crushing of grains. The displacement on the screen and the rotor system changes periodically in the steady state. At the same time, in the steady state, the drilling torque of each screen and the rotating pair of the rotor system is the same. The material is crushed by the high-speed rotating hammer. The effect of crushing through the screen at a time. The structure is simple, the versatility is strong, and the production efficiency is high. The research results provide support for the subsequent research on the structural strength of the system.

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