

Screening Kinematics Analysis of Cleaning Organs and Extractives

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Abstract. Cleaning sieve is an important part of grain combine harvester, which directly affects the performance of grain combine harvester. In this paper, according to the cleaning requirements of the grain combined harvester, the cleaning and movement characteristics of the cleaning sieve are considered, the screening principle of the cleaning sieve is analyzed, and the kinematic analysis of the cleaning mechanism is carried out. Qualitative analysis of the kinematics and kinetics of the corn extractives on the sifting screen is based on traditional theory, and the movement tendency of the corn extractives on the cleaning sieve is analyzed by discrete element software.

1. Introduction

The cleaning device is an important part of the combine harvester. It is mainly to separate the corn grain and other impurities such as straw, and its working performance directly affects the work performance of the whole machine [1]. In the process of optimizing the structure of the cleaning device, the traditional machinery is only to roughly change its structure [2]. The parameters in the process of cleaning, such as the parameters of the air flow, the parameters of the screening sieve structure and the working parameters of the vibrating screen, are seldom discussed, especially the data on the form and kinematics of the corn extractives during the screening process. In addition, in the process of harvesting corn, sacrificing cleanliness is often used to ensure the loss rate, resulting in higher impurity rate of harvested corn kernels.

The screening speed and screening quality of the corn extractives on the screen will directly affect the efficiency of the whole machine and the impurity rate of the corn grain. Therefore, the study of the kinematics and dynamics of the corn extractives in the screening process has a very important influence on the work of the grain combined harvester.

(1) It not only promotes the development of corn harvest mechanization, but also has great significance for developing a new type of combine harvester suitable for maize harvesting and cleaning, low energy consumption and high production efficiency.

(2) The motion characteristics of the cleaning screen mechanism are studied, which directly affect the cleaning ability, cleaning performance and cleaning effect of the cleaning equipment. Therefore, it can provide abundant materials for the selection of cleaning device, and provide a theoretical basis for designing a good cleaning device.



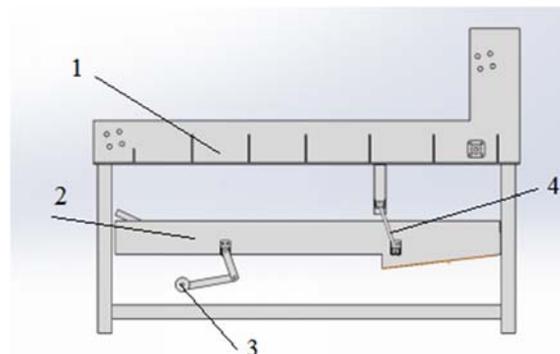
2. The screening principle and dynamic analysis of the cleaning sieve

There are two types of cleaning sieve on the combine harvester, which are slider type cleaning sieve and rocker type cleaning sieve. Their characteristics are simple structure and suitable for small and medium combined harvesters. This paper mainly studies the crank rocker cleaning sieve.

3. The screening principle and mechanism analysis of cleaning sieve

The cleaning sieve is mainly screened by using the principle of different size and material properties between corn kernels and debris, so as to obtain clean corn kernels. When there is a suitable air field above the top of the cleaning sieve, the cleaning efficiency of the cleaning sieve can be effectively raised. Therefore, the general combined harvester will be used in combination with the fan. When the harvester is working, the corn prolapse after threshing is dropped onto the screen surface of the cleaning sieve through the grid concave plate. The simple harmonic motion of the cleaning sieve causes the corn prolapse to be affected by inertia force. The size and direction of the inertia force of each corn extractives are different, but these inertia forces can be divided into the force along the direction of the screen and the force perpendicular to the direction of the screen, so that the corn is thrown up and slid along the screen, thus getting more opportunities for screening and improving the screening rate.

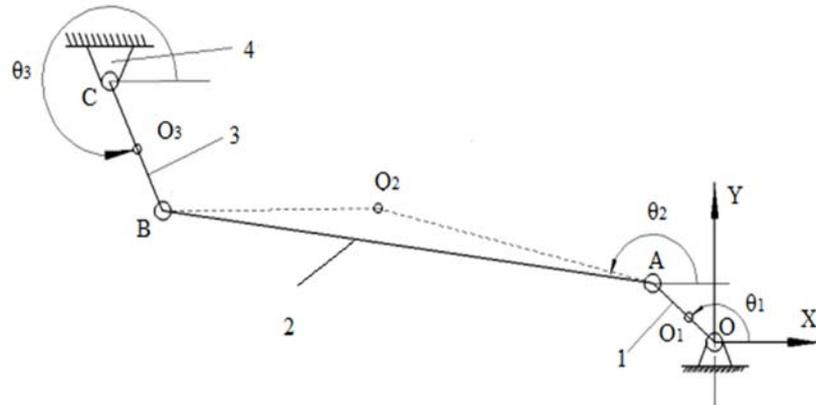
The motion principle of the cleaning device is crank rocker mechanism, as shown in Figure 1, including the frame, the cleaning sieve, the eccentric wheel and the hanger. When the device works, the driving force provided by the engine drives the eccentric wheel to move to the connecting rod, and the connecting rod drives the reciprocating movement of the cleaning screen to realize the movement of the whole mechanism.



1. The frame 2.the cleaning sieve 3.the eccentric wheel 4.the hanger

Figure 1. The solid drawing of the cleaning device

The cleaning mechanism is simplified to crank rocker mechanism, as shown in Figure 2. The eccentric wheel (or crank) of the rocker type cleaning mechanism is articulated with one end of the cleaning sieve, the other end of the cleaning sieve is articulated with one end of the hanger, and the other end of the hanger is connected with the frame. When the cleaning mechanism works, the rotation of the eccentric wheel drives the screen surface to move reciprocally.



1. The eccentric wheel 2.the cleaning sieve 3.the hanger 4.the frame

Figure 2. A simple drawing of the crank rocker cleaning mechanism

3.1. The kinematic analysis of the cleaning sieve

In this paper, an analytical method is used to model the kinematics of the cleaning screen and establish the displacement equation. The absolute coordinate system XOY is set up with the center O of the rotation center of the eccentric wheel, which is in the positive direction of the X axis horizontally, and vertically upward as the positive direction of the Y axis, as shown in Figure 2. In order to make the research connected with the reality, the mechanism parameters of the crank rocker cleaning mechanism are taken from the solid structure parameters of the cleaning sieve shown in Figure1. The parameters of each structure are as follows: $L_1 = L_{OA}$, $L_2 = L_{AB}$, $L_3 = L_{BC}$, O1, O2, O3 are centroid of rods L1, L2 and L3 respectively, and the acceleration of crank rocker is ω . Therefore, the kinematic model of the mechanism is as follows:

$$\begin{cases} A = L_1 \times [\cos \alpha_1, \sin \alpha_1]^T = [x_A, y_A]^T \\ V_A = \frac{dA}{dt} = L_1 \times \omega \times [-\sin \alpha_1, \cos \alpha_1]^T = [v_{xA}, v_{yA}]^T \\ a_A = \frac{dv_A}{dt} = L_1 \times \omega \times [-\cos \alpha_1, -\sin \alpha_1]^T = [a_{xA}, a_{yA}]^T \end{cases} \quad (1)$$

$$\begin{cases} B = A + L_2 \times [\cos \alpha_2, \sin \alpha_2]^T = [x_B, y_B]^T \\ V_B = \frac{dB}{dt} = V_A + L_2 \times \dot{\alpha}_2 \times [-\sin \alpha_2, \cos \alpha_2]^T = [v_{xB}, v_{yB}]^T \\ a_B = \frac{dv_B}{dt} = a_A + L_2 \times \ddot{\alpha}_2 \times [-\cos \alpha_2, -\sin \alpha_2]^T = [a_{xB}, a_{yB}]^T \end{cases} \quad (2)$$

Where: A, B - displacement vector of hinge points A and B;

V_A, V_B - the velocity vector of hinge points A and B;

a_A, a_B - the acceleration vector of the hinges A and B;

x_A, x_B - the horizontal displacement of hinges A and B;

y_A, y_B - the vertical displacement of hinges A and B;

v_{xA}, v_{xB} - the horizontal velocity of hinges A and B;

V_{yA} , V_{yB} - the vertical velocity of hinges A and B;

α_1 - the crank angle;

α_2 - the horizontal angle of the screen AB.

4. The movement form and kinematics analysis of the corn extractives in screening process

4.1. Analysis of the movement form of the extractives during the screening process

There are many relative movement forms of corn prolapse on the screen surface, such as throwing, sliding and relative rest. The discrete element software was used to simulate the process of corn cleaning. Three corn extractives were randomly selected and their trajectories were traced to obtain the motion profile of the corn extractives, as shown in Figure 3. According to the trajectories of the corn extractives, we can see the movement forms of the extractive in the cleaning process. Some extractives leave the sieve surface of the cleaning sieve under the action of the inertia force and do the throwing movement. Some of the extractives do slip motion along the screen surface of the cleaning sieve, and the extractives are still relatively static under the action of the friction force. In this paper, the throwing motion and sliding motion are analyzed.

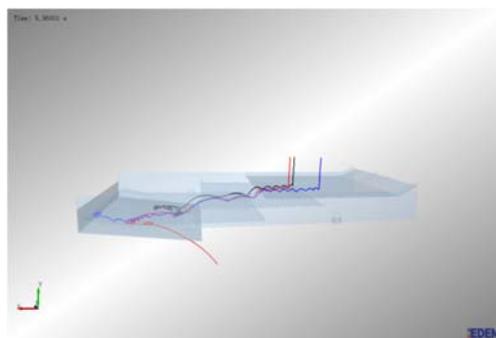


Figure 3. The trajectory map of the corn extractives

4.2. The kinematic analysis of the extractives during the screening process

In this paper, a single corn extractive was selected as the research object, and its stress analysis was carried out on the screen surface. Based on the hinge point B on the cleaning sieve, the relative coordinate system xoy is set up, along the screen surface as the positive axis of the X axis, and perpendicular to the sieve as the positive direction of the Y axis. According to the coordinate transformation, the horizontal angle of the screen surface AB is α_2 in the xoy , that is $\theta = \pi - \alpha_2$.

(1) The sliding motion

The slipping movement occurs during the the cleaning process of corn, so there is a slip displacement of the corn extractives relative to the screen surface, and then there is relative velocity and relative acceleration relative to the screen surface. In this paper, the relative acceleration is analyzed, assuming that the acceleration direction is positive along the screen surface. During the screening process, there are two cases of the downward sliding and upward sliding of the corn extractives. In these two cases, the direction of the speed of the corn extractives is opposite, so the direction of the friction force is opposite, and the direction of the acceleration of the slip is the opposite. Therefore, the relative slip acceleration of corn prolapse should be discussed in two cases.

When the frictional force of the extractives is upward, as shown in Figure 4:

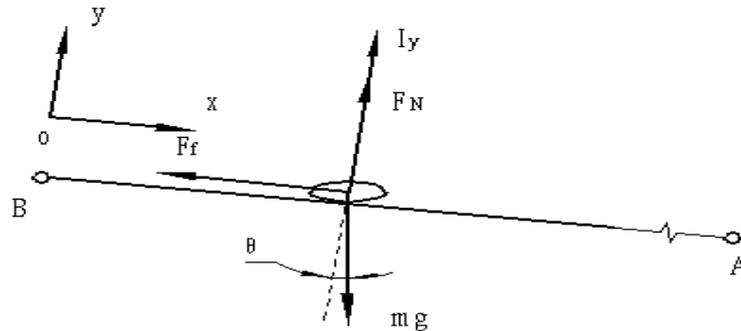


Figure 4. Force analysis of corn in the direction of friction upward

According to the actual situation, the condition of slipping of corn prolapse: $F_N > 0$, that is

$$F_N = mg \cos \theta - I_y > 0 \tag{3}$$

Since the horizontal angle of the screen surface AB ranges from 90° to 180° , the $\cos \theta > 0$ is always set up. It can be seen that only when $I_y < mg \cos \theta$ is applied, can the slipping motion of corn extractives occur during the screening process.

At this time, the slipping movement of the corn extractives will appear. Thus, $ma = mg + I_x - F_f$, that is

$$a = \frac{mg + I_x - F_f}{m} \tag{4}$$

When the frictional force of the extractives is downward, as shown in Figure 5:

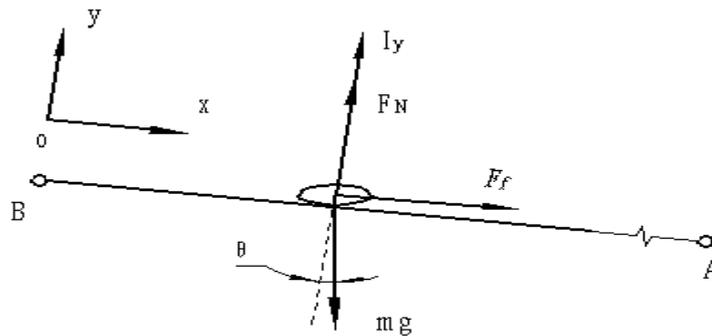


Figure 5. Force analysis of corn in the direction of friction downward

At this time, the slipping movement of the corn extractives will appear.

Thus, $ma = mg + I_x + F_f$, that is

$$a = \frac{mg + I_x + F_f}{m} \tag{5}$$

(2) *The throwing motion*

The condition for throwing motion on the sieve surface is that the supporting force of the sieve to the corn prolapse is zero. Thus, $F_N = 0$, that is

$$F_N = mg \cos \theta - I_y = 0 \quad (6)$$

Since $A > 0$ is always set up, it is only when the direction of the inertia force of the corn extractives is upward and perpendicular to the screen, that is, the direction of the acceleration of the cleaning sieve is perpendicular to the screen and downward, when the corn is thrown, the throwing movement will be produced.

5. Conclusion

(1) This paper briefly introduces the screening principle of the cleaning sieve, constructs the model of the cleaning mechanism, analyzes the kinematics of the cleaning sieve, and establishes the kinematic equation of the crank rocker type cleaning sieve.

(2) The movement form of the extractives during the screening process was analyzed by the discrete element software to simulate the cleaning process of corn, and the kinematics of the corn extractives during the screening process was analyzed.

Acknowledgements

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