Dynamic Simulation Research on Chain Drive Mechanism of Corn Seeder Based on ADAMS

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Abstract. In order to reduce the damage to the chain and improve the seeding quality of the seeding machine, the corn seeder has the characteristics of the seeding quality and some technical indexes in the work of the corn seeding machine. The dynamic analysis of the chain drive mechanism is carried out by using the dynamic virtual prototype. In this paper, the speed of the corn planter is 5km/h, and the speed of the simulated knuckle is 0.1~0.9s. The velocity is 0.12m/s, which is equal to the chain speed when the seeder is running normally. Of the dynamic simulation of the movement and the actual situation is basically consistent with the apparent speed of the drive wheel has changed the acceleration and additional dynamic load, the chain drive has a very serious damage, and the maximum load value of 47.28N, in order to reduce the damage to the chain , As far as possible so that the sowing machine in the work to maintain a reasonable uniform speed, to avoid a greater acceleration, the corn sowing machine drive the design of a certain reference.

1. Introduction
At present, the widely used power transmission mechanism on the corn planter is still the traditional chain drive mechanism, the performance of the corn seeder transmission mechanism is one of the key technologies of seeding quality. Chain drive mechanism has been used in many times because of its reliable working performance, simple structure, low manufacturing cost and low cost, which is the most widely used driving mechanism in the field of corn seeder [1].The chain drive mechanism is the core mechanism of the sowing machine drive. The design quality of the chain drive directly affects the transmission performance, seeding efficiency and seeding quality of the planter [2]. Corn planter condition is very complex, the chain transmission mechanism is the main reason to influence the planting quality, in order to study the work of transmission mechanism of corn planter and its actual dynamic characteristics. Using SolidWorks and ADAMS as tools, this paper focuses on transmission mechanism of a corn planter.
2. Dynamic model establishment

2.1 The establishment of the whole model
In the SolidWorks 3D software, each part and part model of the seeder is bound together through certain connection relation, so that the whole machine assembly can complete the specific seeding function. Through the assembly of interference, collision checks and dynamic gap detection, to ensure that any part of the space does not appear overlap with each other. After interference check, found that there is no interference in the assembly phenomenon, to meet the assembly requirements. Corn planter machine assembly diagram, as shown in Figure 1. The main parameters are: 1750mm × 1400mm × 950mm, ground wheel diameter of 600mm.

![Corn planter machine assembly diagram](image)

**Figure 1** The whole machine assembly drawing of the planter

2.2 The establishment of chain drive model
The roller chain drive mechanism consists of active sprocket, driven sprocket and roller chain, the roller chain is the inner and outer chain plate, pin and sleeve roller composition. This article uses the chain link 05B chain link, the main parameters shown in Table 1. Sprocket with chain number 05B sprocket, the main parameters shown in Table 1 [3]. Design chain drive with SolidWorks software, according to the design parameters designed by the chain drive three-dimensional model diagram, as shown in Figure 2 [4].

| Link parameters          | Numerical value | Sprocket parameters          | Numerical value |
|--------------------------|----------------|-----------------------------|----------------|
| Parameter name           |                | Parameter name              |                |
| Chain number             | 05B            | Chain number                | 05B            |
| Pitch                    | 8.00mm         | Number of teeth             | 20             |
| Roller diameter          | 5.00mm         | Pitch circle diameter       | 51.140mm       |
| Shaft pin diameter       | 2.31mm         | Root circle diameter        | 46.140mm       |
| Chain plate thickness    | 0.80mm         | Addendum circle diameter    | 54.820mm       |
| Inner chain width        | 3.00mm         |                            |                |
| Inner plate height       | 7.10mm         |                            |                |
1. Active wheel  2. Chain   3. Driven wheel

**Figure 2** Chain drive assembly diagram

3. **Dynamic Analysis of Transmission Mechanism**

3.1 *Force analysis of chain drive*

As shown in Figure 2, the chain drive in the work, there are tight side tension and loose pull [5]. If you do not count the dynamic load in the drive, the tight side tension and loose pull force were:

\[ F_1 = F_e + F_c + F_f \]
\[ F_2 = F_e + F_f \]

Where \( F_e \)—Effective circular force(N);
\( F_c \)—Centrifugal force caused by the tension(N);
\( F_f \)—Overhanging tension(N).

Effective circular force:

\[ F_e = \frac{M_2}{r_1} = \frac{M_1}{r_2} \]

Where \( M_1 \), \( M_2 \)—Active wheel, driven wheel required torque(N·m);
\( r_1 \), \( r_2 \)—Active wheel, driven wheel pitch circle radius(m).

The pulling force caused by the centrifugal force is:

\[ F_c = qv^2 \]

Where \( q \)—The quality of the chain unit length(kg/m);
\( v \)—The speed of the chain(m/s).

Assuming the lower part of the hanging chain from the middle of the chain and the chain of the starting point of the moment to take the moment, by the balance of conditions:

\[ F_f f = \frac{qga}{2} \times \frac{a}{4} \]

Where \( q \)—Length of chain unit length(kg/m);
\( g \)—Gravitational acceleration(m/s²);
\( a \)—Chain drive center distance(m);
\( f \)—Sagging(m).
3.2 The force calculation of chain drive

In order to ensure the quality of planting, we must use the operating speed in the operation, usually the speed of the corn planter should not be greater than 7km/h [6]. In this paper, the speed of the corn planter is 5km/h. It can be seen from the design of the whole machine. The diameter of the ground wheel is \( D = 600 \text{mm} \). The ground wheel is fixedly connected with the chain drive wheel, and the chain speed is 0.12m/s.

The required torque for the normal operation of the planter is 5N·m and the effective circumference of the chain is:

\[
F_c = \frac{M_2}{r_1} \approx 195.54N
\]  

(6)

Chain material is commonly used 45Mn, chain linear density is 4.25kg/m, then the centrifugal force caused by the pull:

\[
F_c = qv^2 \approx 0.06N
\]  

(7)

When the chain sag is 10mm, the tension of the chain is:

\[
F_f \approx \frac{qgA^2}{8f} = 40.82N
\]  

(8)

So the tight side of the chain pull fore:

\[
F_1 = F_c + F_c + F_f = 236.42N
\]  

(9)

The number of sprockets is 20, the transmission ratio of the chain drive is 1, its wrap angle, so there are 10 teeth within the angle. As the sprockets and chains are rigid, the average load of each sprocket is:

\[
F = \frac{2\pi F_1}{\alpha \zeta} \approx 47.28N
\]  

(10)

4. Dynamics Simulation and Result Analysis

4.1 Import models and add constraints

In the SolidWorks software, save the chain drive model as a Parasolid (*.x_t) file, import the file in the ADAMS virtual prototyping system, and perform kinetic analysis of the chain drive. Imported simulation model, the need to set the quality of the model, centroid, inertial tensor, the model to add constraints [7]. The active wheel, the driven wheel and the earth are the rotation sub-constraints, and the link between the link and the link is a rotation pair. The sprocket is engaged with the chain to drive the whole system. Because the chain and the sprocket are engaged with the high side of the line, and the meshing of the sprocket and the chain is complicated, it is difficult to define the motion pair between them. Without affecting the simulation results under the premise of the need to define a chain between the chain and the contact, contact type for the physical contact [8 ~ 9].

After defining the constraint relationship, you also need to determine the contact parameters. Contact parameters: metal and metal stiffness between 1.0E + 008N / m; contact index Force Exponent take 1.5; Damping refers to the maximum damping, take the stiffness of 0.1%. Penetration Depth takes the system default value of 1.0E + 004. Static Coefficient and Dynamic Coefficient of the steel and steel are taken at 0.15 [10-11].
4.2 Other settings
Solver settings, integrator (General) generally choose the default GSTIFF. When choosing Formulation, select I3 or SI2 according to the different requirements of the simulation. I3 for the default value, simulation robust, high efficiency, and SI2 simulation more stable, effective control divergence, not easy to error, but the speed is 10 times slower than I3. In order to improve the simulation results, the simulation is more stable, this paper chooses SI2. Corrector selects Modified, other settings default [12]. Add the driver to make the simulation, the left sprocket to add the rotation drive. In order to make the simulation results closer to the actual situation, we need to set up the Step function for the drive sprocket, and set the Step function as STEP (time, 0,0,0.1,270d) + STEP (time, 0.9,0,1,-270d).

4.3 Simulation analysis
In order to study its kinetic properties, kinetic simulation is required. Set the simulation time to 1s, Steps set to 200, click to start the simulation. After completion of the simulation, into the post-processing module (PostProcessor), through the measurement and other functions, you can get each component speed, angular velocity, angular acceleration, force and other curves.

As can be seen from Figure 3 and Figure 4, the speed of the link between 0.1 and 0.9 s is slightly fluctuating at 0.12 m/s, approximately uniformly moving and satisfying the chain speed in the above. Indicating that the speed of the chain changes with the actual situation is basically consistent.

![Figure 3](image1.png)

**Figure 3** The speed change of the chain tight inner link 34.

![Figure 4](image2.png)

**Figure 4** The speed change of the chain loose inner link 100.
As can be seen from Figure 5, the angular velocity of the driven wheel is accelerated from 0s to 0.1s, and decays to 0.9s. There is a significant change in angular velocity between 0.1 and 0.9 s, indicating a change in acceleration and additional dynamic load.

![Figure 5](image)

**Figure 5** The angular velocity of the driven wheel.

It can be seen from Figure 6, the angular acceleration of the driven wheel in the 0~0.5s when there is a significant change, the emergence of a series of vibration peaks, showing a significant impact vibration phenomenon, indicating the contact between the driven wheel and its complex and complex. The chain has a very serious damage, and to speed up the sprocket and chain wear. Therefore, the chain drive mechanism should be relatively smooth start, the maximum speed to maintain a reasonable, in order to reduce the chain and sprocket wear and damage.

![Figure 6](image)

**Figure 6** The angular acceleration of the driven wheel.

It can be seen from Figure 7, the contact force between the driven wheel and the inner link occurs between 0.15 and 0.5 s, and the other time is not in contact with the sprocket, the curve is approximately 1/4 sine wave, the maximum is 47.28N, Which changes greatly in the 0.3s, indicating the existence of the drive wheel and the inner section of the wear and impact, resulting in the drive wheel produced a significant vibration. Therefore, in the corn planter work, should be as much as possible to maintain a reasonable uniform movement, to avoid greater acceleration, improve the quality of corn seeding sowing.
5. Conclusions

In this paper, the model of the corn planter and the model of the transmission mechanism are established by the three-dimensional modeling software SolidWorks. The dynamic characteristics of the transmission mechanism are studied by ADAMS. Conclusions are as follows:

1) By the analysis of dynamics of chain drive, the wheel angular velocity from 0s to 0.1s began to accelerate, accelerate to maximum, 0.9s started to slow down, until the 1s down to zero; in the 0.1~0.9s between the angular velocity of obvious change, indicating that the change has occurred in the acceleration and additional dynamic load; chain dynamics simulation of the situation and the actual situation is basically consistent.

2) By the analysis of dynamics of chain drive, the corn planter in the working process, the driven wheel angular acceleration of the chain transmission mechanism show significant changes in 0~0.5s, a series of vibration peak, have obvious impact vibration phenomenon; from the contact force of the driving wheel and the inner link of 85 occurred in the 0.15~0.5s, the maximum value is 47.28N, the complex contact forces resulting from abrasion and impact between the driving wheel and the driven wheel inner link, has obvious vibration phenomenon.

3) In the corn planter work, the amount should maintain a reasonable uniform movement to avoid a greater acceleration and improve the quality of corn seeding sowing. The kinetic analysis of the transmission mechanism of the corn seeder has shortens the development cycle improves the working efficiency, and has some reference significance.

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