Virtual Modeling and Simulation of Transplanting Mechanism with Non-circular Planetary Gears

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Abstract: This article deploys an exploratory development of super rice High-performance transplanter transplanting mechanism with non-circular Gears by dint of rice transplanter transplanting mechanism analog machine according to UG software. This research is first to building a model of non-circular Gears designed by researcher before, and then assemble the whole to obtain the result of virtual manufacturing with non-circular Gears, and assemble it on the test machine of rice transplanter test machine, also analysis the Kinematic Principle of Simulation result by UG software. Finally, make the motion trail conform to the agronomy requirement according to correcting and consummating the fember unqualified.

Keywords: transplanting mechanism, UG, assemble, Simulation.

1. Introduction

The background of this article is the foundation of natural science in Guangdong---the exploratory development of super rice High-performance transplanter transplanting mechanism with non-circular Gears, which applies simulation method by UG software for analysis. Super rice is the technological research findings belong to academician Longping-Yuan. Because of the difference to other rice, the transplanter for it would be more fidelity, which involve in agronomy, mechanical engineering, soil-machine, Systems and multi-body system kinesiology/dynamics. In order to develop super rice High-performance transplanter, the aim of invented and simulation is not only let constructors familiar with each details of products, inducing design mistake, but make the contrivation and revision more simple, moreover, it could finish the serialization of design. Otherwise to utilize the UG software, we could complete the analysis of mechanism kinematics, dynamics simulation and finite element, and also could elevate the reliability, stability and versatility of agricultural machinery design. This research is mainly to virtual manufacturing and simulation of transplanting mechanism. Based on the prepared machine part, using the UG software, it assembles the mechanism and simulates movement device, vertical feeding seedlings, transplanting mechanism, and analysis the motion trail of feeding, throwing and transplanting. Futhermore, according to UG software, this article obtains the motion analysis and interference analysis of the whole motion.
2. Virtual Manufacturing of Transplanting Mechanism

The virtual manufacturing of transplanting mechanism is based on the design of non-circular gears. First it needs a digital modeling with each parts, and then put them together, finally experimentize on the test machine.

2.1. Structure of Transplanting Mechanism

As shown in the figure 1, there are five congruent eccentric gear on the diagram of Transplanting Mechanism with eccentric gear gears. The two pair gear wheel symmetrical distribute on the both sides of sun gear, and the transplanting arms are fixed on planet wheel. The axis of rotation of planet carrier and sun gear are together. While working sun gear is fixed, but planet carrier turns run, and two idlers run round with the sun gear, so that spurs the two planet gears swing in circle. Each spot on the transplanting moves as composite motion: the transport motion is constant speed, clockwise, circular motion around planet carrier, the relative motion is nonuniform speed, retrograde motion around planet gear. These construct the special locus and pose of seeding needle.

2.2. Feature Modeling of Transplanting Mechanism

(1) Feature modeling of gears

Add each parameters of gears to list: modulus M=2, number of gears z=21, pressure angle ALPHAs20, addendum coefficient HAX=1.0, addendum space CX=0.25 and tooth width B=6.22, and the other values of addendum HA, dedendum HF, modification coefficient X, root diameter DA, base diameter DB, root diameter DF and reference diameter D all assign 0. Driwing rolling circle, setting up gear relation, defining gear sides, founding gear contour line are the difficult point of gears foundation with involute equation in the opened notepad.

\[ r = \frac{db}{2}; \theta = \frac{\pi}{45}; \]
\[ x = r \cos(\theta) + r \sin(\theta) \frac{\theta}{180}; \]
\[ y = r \sin(\theta) - r \cos(\theta) \frac{\theta}{180}; \]
\[ z = 0; \]

After the management above, three-dimensional digit gears would be obtain. As shown in the figure 2.
(2) Feature modeling of jack-shaft
Based on the parametric gears, the jack-shaft could be drawing by altering proportional parameter. As shown in the figure 3.

(3) Plantation arms
Throwing and seeding of machine are achieved by plantation arms directly. It could imitate the pressing down pose like hand-made. Pushing mechanism involve in spring, staff, fork, cam and other parts. As shown in the figure 4.
Assemblage of transplanting mechanism, as shown in the figure 5.

3. Motion simulation of transplanting mechanism

Motion simulation could be divided into two parts as move container device and transplanting mechanism. Kinematic pair is installed based on conjunction. Because of the much of parts on test-bed, and low-end configuration of computer, the computer would appear to be lower speed or even crash, if using the general assembly for simulation. So it is the best choice to set up conjunction and analyse motion according to each kinematic mechanism.

After the assembly of the inserting mechanism is completed, the virtual kinematics analysis of the assembly is carried out by using ADAMS software. In this section, kinematics simulation of the splitting mechanism is carried out from the angle of mechanical transmission. Angular velocity of non-circular gear and torque of eccentric gear are obtained. meshing position model of corresponding state is picked up.

After entering the ADAMS post-processing module, the angular velocity curve of the non-circular gear obtained by simulation is drawn, as shown in Figure 6. During the two cycles of non-circular gear moving around eccentric gear, the change of angular velocity is periodic and regular.
According to the result of motion simulation, the motion rail of transplanting mechanism with non-circular planetary gear trains is consistent with requirement of agronomy.

![Angular Speed Curve of Non-circular Gear](image1)

**Fig.6** Angular Speed Curve of Non-circular Gear

Draw the eccentric gear torque curve, as shown in Figure 7. The periodicity of eccentric gear's torque curve is faintness in two cycles, and its jump and float range is very large. It shows that the abrupt change of torque in the meshing process between non-circular gear and eccentric gear is serious, which fully shows the complexity of its meshing situation.

![Torque Curve of Eccentric Gear](image2)

**Fig.7** Torque Curve of Eccentric Gear

Combine these two curves into a chart. As shown in Figure 8, the red curve is the eccentric gear torque curve and the blue curve is the non-circular gear angular velocity curve. It can be seen that the abrupt change of eccentric gear torque occurs when the angular velocity of non-circular gear increases or decreases gradually. When the angular velocity of non-circular gear is small or maximum, the mutation of eccentric gear torque is obscure.
In the three-dimensional software UG, the entities of parts and components of the inserting mechanism are established. Components are assembled to form assemblies, and then virtual simulation is carried out in ADAMS software. Through kinematics and dynamics simulation analysis, the speed and torque of non-circular gear are obtained. According to the result of motion simulation, the motion rail of transplanting mechanism with non-circular planetary gear trains is consistent with requirement of agronomy.

4. Conclusion
(1) interference phenomenon can out be found in the design and simulation of transplanting mechanism with non-circular planetary gear trains;
(2) the motion simulation of transplanting mechanism with non-circular planetary gear trains proves that the structure is fit to the requirement of agronomy.

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