Dynamic Analysis of Reed Cutting Mechanism and the Structure Design of Reed Cutting Mechanism

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Abstract: The reed cutting mechanism is the core component of cutting system for growing in water. It is necessary that the cutting mechanics model and its dynamics equations are established before the structure is designed. This can help to understand the force of cutting mechanism and analysis the motion characteristics of the components, and this also help to design reasonable structure. All this not only reduce the repetition labor but also can choose the component, and also improve the reliability of the cutting device. The device is simple in structure, and is practical and reliable, and has high performance price ratio.

Key words: reed cutting device; dynamics analysis; structure design

INTRODUCTION

With the increase of labor costs, some enterprises which contract with growing in the water so as to improve the working environment of workers and the efficiency of harvesting. The reed height which grows in water is generally about 2~3.5m, and the diameter of reed is about 20mm generally, the growth density is relatively high, about 25 plants / m² or so. This design and research is entrusted by a company. The reed cutting device must meet:

1) Cutting height can be adjustable;
2) The reeds after be cut can be lodging in one direction.

The mechanical harvesting device is designed for reed harvesting in small water area, the utility model has advantages of simple structure and high efficiency of harvesting. And mainly questions are harvested and lodging. Water governance hope to use reed harvesting device to harvest the reed. This issue is to solve the problem that how to harvest reeds and how to make the harvested reed lodging in one direction.
INTRODUCTION OF THE REED CUTTING DEVICE STRUCTURE

The reed cutting device is adopted belt transmission mode which is driven by a motor. It is not only simplifies the structure but also reduces the weight of the whole machine. The reed cutting device is hung on the front of the hull which is composed of a cutting mechanism, reed mechanism, lodging mechanism and cutting height adjusting mechanism. The power system uses the power which drive the hull forward, such as using a diesel generator, and the output power can be used to drive the cutting device and the lodging of the motor. The reed is divided into reed device separately in the process of the boat forwarding and the height of cutting device can be adjusted by the screw nut pair connection. The reed lodging is guided by spiral drum which is driven by a motor, it can make cutting reeds lodging in one direction. The structure of the device is shown in Figure 1. Figure 2 is the 3D graph of cutting mechanism.[1-7]

DYNAMIC ANALYSIS OF CUTTING MECHANISM

In order to increase the cutting force, the cutting mechanism adopts the double action type cutting structure with staggered movement. Figure 3 shows the three-dimensional graph of the cutting mechanism, and the schematic diagram of cutting mechanism is shown in Figure 4. The output power of the motor is transmitted to the drive shaft by the belt which can transmit power to the eccentric wheel. The eccentric wheel drives the blade seat to move, the upper and lower parts of the blade base are respectively driven by the upper and the lower eccentric wheels. The power of the motor of the cutting device is 2.2kW, and the speed of the motor is n=960rpm.
THE MOTION EQUATION OF THE CUTTING PART AND THE ANALYSIS OF ITS CHARACTERISTICS

As shown in Figure 4, the cutting mechanism is a crank slider mechanism. The center of the rotation of the crank is the axis O of the drive shaft, the length “e” of the crank is the distance between the center of the eccentric wheel and the axis of the drive shaft, the slider 1 is an eccentric wheel. The eccentric wheel slides in the groove of the blade seat; the slide block 2 represents the upper blade base and the blade and the lower blade base and the blade. The “α” is the angle between the crank and the X shaft, the “ω” is angular velocity of rotation of a crank. The drive shaft speed is “n₁”.

Therefore, the motion equation of the center of mass of the slide block 1 which in the slider mechanism is:

\[ \begin{align*}
&x_{o2} = -e \cos \alpha = -e \cos \omega t; \quad y_{o2} = e \sin \alpha = e \sin \omega t \\
&x_{o2} = e \sin \alpha = e \cos \omega t; \quad y_{o2} = e \cos \alpha = e \omega \cos \alpha; \\
&\ddot{x}_{o2} = e \omega^2 \cos \omega t; \quad \ddot{y}_{o2} = -e \omega^2 \sin \omega t
\end{align*} \]

(1)  (2)  (3)

The movement speed of center O_2 of slide block 1 is \( v_{o2} = e \omega \), its acceleration is \( a_{o2} = e \omega^2 \); the movement speed in the direction of X axis of slider 2 is a set of blades that cut the reed’s cutting speed \( v_1 \) or \( v_2 \). It is equal to the component of the center point O_2 of the slider 1 in the direction of the X axis. Therefore, the cutting speed of the blade and the blade base of the reciprocating cutting is \( v_1 \) or \( v_2 \):

\[ v_1 = v_2 = e \omega \sin \omega t \]

(4)

By the formula (2), (3) and (4) can be seen, when \( \alpha = 0^0 \) or \( 180^0 \), that is when the eccentric center is spun to the left or the right side, the cutting speed is zero at this point, and the acceleration of this position is the maximum. The acceleration of the cutting knife is proportional to the square of the rotational speed of the crank. The bigger the acceleration, the vibration of the cutting table will be larger, so the speed of the crank should be controlled within a reasonable range[2,5].

ANALYSIS ON THE INERTIA FORCE OF CUTTING TABLE CUTTING

There are many factors that affect the cutting force of reed cutting machine, including: the cutting height of reed, the cutting speed of reed, the change of the
growth density and feed rate of reed. Figure 4 is the force analysis of the cutting component. The main force includes an active force F which is generated by the active torque T driven by the driving crank. When the cutting table is cutting, the cutting resistance $F_1$ of reed in cutting, friction force $F_g$ generated by the weight of the blade and the blade base, the friction resistance of the blade base to the eccentric wheel $F_{MN}$, the inertia force of the cutting assembly $F_a$.

According to the Darren Bell principle, we can get $F + F_1 + F_g - F_a = 0$, the Cutting inertia force $F_a$ in the formula can be obtained from the formula:

$$F_a = Ma = Me \omega^2 \cos \alpha$$  \hspace{1cm} (5)

It can be seen that the inertial force is maximum when the center of the eccentric wheel rotate to the left or the right end position. When $\alpha = 90^\circ$ or $270^\circ$, the center of the eccentric wheel is the center of mass of the slide block 1 in the vertical direction at this time, and at this point, the cutting speed is the biggest, the acceleration is zero, and the inertia force is zero[2].

**MAIN STRUCTURAL DESIGN**

**Structure Design of Cutting Part**

The output power of the motor is transmitted to the eccentric wheel through the drive of the main and driven belt wheel, it drives the cutting tool to do the reciprocating linear motion. The external force couple moments $T_i$ which acting on the driving shaft. The instantaneous cutting force is different when cutting. The change of speed will cause the change of cutting force, so it is difficult to calculate the instantaneous cutting force when cutting, which is based on the principle of equal power, that is $T \omega = Fv$.

Slide 1 is to drive the cutting knife to do straight reciprocating motion of the eccentric wheel, which the material of the eccentric wheel is 9SiCr Steel or CrWMn, and it is designed double bond type which drives shaft. The size of the eccentric distance according to the reciprocating stroke is 70mm. The minimum thickness of the eccentric wheel needs to meet the requirements of safe material stress[1]. The assembly drawing of the cutting table assembly is shown in Figure 5. Figure 6 is a section of A-A in Figure 5.

![Figure 5. Assembly drawing of cutting assembly.](image1)

![Figure 6. A-A section view of Fig.5.](image2)
The cutting device is the structure which adopts the alternating motion of the double acting blade type, which the upper cutting blade are installed on the upper blade seat, the lower cutting blade are arranged on the lower blade seat. The upper and lower knife seat are installed in suspension in the bow of the tool holder of channel, the holes in the middle part of the upper and lower blade holder is used to install the eccentric wheel.

The Structure Design of Reed Lodging System

Because the reed after the cut will be implicated in each other, they will fall in the cutting mechanism. If the reed being cut can not be properly guided to lodging in one direction, that the subsequent finishing work about reed will be difficult. The reeds are not easy to be integrated by artificial or mechanical. A spiral roller device which can make reeds lodging in one direction after they are cut has been designed, this is mainly through a rotary drum which rotates with lodging reed in one direction of dumping. The mechanism is arranged on the cutting mechanism, as shown in Figure 1. Drive motor drives the spiral drum around its own axis which mainly through the driving wheel, a conveyor belt, a driven wheel, the spiral roller blades in the spiral drum rotation will be cut reed to the side of the toggle, led by cutting reeds to lodging in one direction.

CONCLUSION

(1) This reed cutting device has the advantages of simple and reliable structure, low cost, improved working conditions of the workers, and greatly improved the cutting efficiency of the reed growing in water, and has high cost performance, and has great application value and promotion potential.

(2) By the analysis, we can know that the eccentric wheel which is the center of the slider 1 in the most left and right of the two limit position, when the connection of the two limit position should be through the rotation center of the crank O, so that the average speed of the cutting knife in the round trip is equal.

(3) The rotating speed of the crank has great influence on the acceleration of the cutter, it is proportional to the square of the rotational speed. Therefore, the rotation speed of the crank should be reduced. The device adopts a belt transmission, the speed of the motor is carried out a reasonable reduction.

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