

Design of Picking Roller for Corn Harvester Picking Machine and Selection of Hydraulic Motor

Heng Wang¹, Shukun Cao^{1*}(Corresponding author), Xiangqian Xu², Tao Han², Hejia Guo²

¹ Nanxin Zhuang West Road 336 Jinnan, School of Mechanical Engineering, University of Jinan, Jinan 250022, Shandong Province, China

² Dafeng Road 6, Yinzhou, Shandong Jindafeng Machinery Co., Ltd, yanzhou272100, Shandong Province, China

*Corresponding author's e-mail: 87756997@qq.com

Abstract: In the actual application process, the corn harvester has problems such as high loss rate of fruit and energy waste. This article analyzes the corn picking device, the reason for the high loss rate is found, and a new picking roller is designed. Through the calculation of the force and torque of the picking roller and the chain during the harvesting process of the corn harvester, the power required for the picking device is obtained, and the hydraulic motor model required for the picking device is further obtained. Through design and analysis, we determined the optimum speed of picking roller in corn picking process: 836r/min, picking roll inclination angle: 35°, and picking roll radial size: 75mm. The article determines that the hydraulic motor model is the American white cycloidal motor WS80.

1. Introduction

With the development of China's economy, corn harvesters have also developed rapidly. However, due to the relatively short development time of corn harvesters, corn harvesters have problems of high ear loss rate, high impurity content and high power consumption. [1]The picking device is the main working part of the whole header. The working efficiency of the picking device determines the working quality of the corn harvester and the harvesting header. [2]The picking mechanism should be able to meet the harvesting of corn ears with different growth conditions and reduce the loss rate of grains. [3]It is known from the literature that the structural design of the picking roller is the main reason for the high loss rate. The mistake of hydraulic motor selection is the cause of energy waste. [4]In this paper, the design of the corn harvester picking device and the picking roller are selected to select the matching hydraulic motor to reduce the loss rate of the ear, which provides a theoretical basis for the design of the corn harvester header. This article is of great significance for ensuring the reliability of the harvester and giving full play to the efficiency of the harvester.

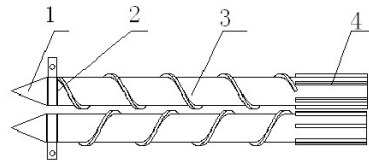
2. Design of the picking roll

2.1 Picking roll structure and working principle

The picking roller device adopts two pairs of reversed and inwardly rotating picking rollers. The guiding cone is the front end of the picking roller, which is a smooth cone, mainly guiding the stem into the picking section. [5]The picking section is a cylinder with threaded ribs, and the two



corresponding picking rolls have opposite threads, and the ears are separated from the plants by squeezing the corn plants. The rear part of the picking roll is a strong pulling section, and the surface has a large rib. The main function is to forcibly discharge the stem part and the straw which has been pulled off to prevent the straw from winding the picking roller. [6]The design of the picking roller is shown in Figure 1. The mounting of the picking roller is shown in Figure 2.



1. Diversion cone 2. Adjusting the bearing 3. Picking the segment 4. Strong pulling section
Figure 1 picking roller design picture

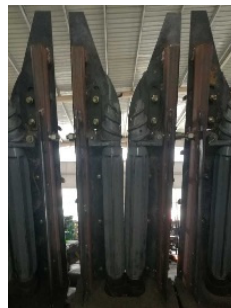


Figure 2 Sewing roll installation physical map

2.2 Mechanical analysis of the picking roll

When the corn harvester is working, the corn stalk passes through the gap between the pair of picking rolls. According to the actual situation, the stem is always in the vertical ground state. The speed of the picking roller is shown in Figure 3.

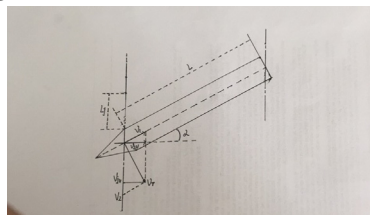


Figure 3 Speed analysis of the picking roller

The time for the corn stalk to pass through the entire picking roll is as shown in Formula 1-1.

$$t = \frac{L_j \cos \alpha}{V_r} \quad (1)$$

In the middle: L_j is the length of the portion of the picking roller through the stalk, m.

V_r is the peripheral speed of the surface of the picking roller, m/s.

v_{jH} is the speed at which the horizontal stalk moves backward relative to the header:

$$v_{jH} = v_r \sin \alpha \quad (2)$$

It can be seen from the above formula that the time t of the corn stalk passing through the picking roll decreases as the inclination angle of the picking roll increases, and the speed at which the stem moves backward relative to the cutting head increases. Therefore, when the picking roller is installed, the angle is inclined at a certain angle, on the one hand, the picking ability of the picking roller for the downward direction of the corn straw can be increased, and on the other hand, the condition

that the picking roller is blocked can be effectively solved. Through actual experience, it is known that the angle of the picking roller is 35° . By looking up the reference literature, it is known that the rotation speed of the picking roller is also one of the key factors affecting the loss of the ear. The rotation speed of the picking roller should match the running speed of the unit. The basis for selecting the speed of the picking roller is shown in Equation 1-3.

$$c = \frac{v_m}{v_0 \sin \beta} = 0.7 \sim 1 \quad (3)$$

In the middle: C-scale factor

v_m - machine forward speed

v_0 - picking roller peripheral speed

β --Picking roll inclination

The speed of the unit and the peripheral speed of the picking roller have an impact on the loss of picking and productivity. When the driving speed of the unit increases, the speed of the picking roller should increase proportionally. When the speed of the picking roller is too large, the impact of the corn ear and the picking roller is large, and the loss rate is larger. If the rotation speed of the picking roller is too low, the contact time between the corn ear and the picking roller is long, which increases the probability of peeling off the grain, and the corn ear is also easily stabbed. The force of picking the ear to pick up the ear is shown in Figure 4. The rotation speed of the picking roller is as shown in Equation 1-4, and the line speed v of the picking roller is taken as 3.5 m/s.

$$n = \frac{v}{\pi D} = \frac{3.5 \times 1000 \times 60}{3.14 \times 75} \approx 836 \quad (4)$$

In the middle: v - picking roller speed

D -The diameter of the root of the picking roller

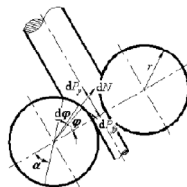


Figure 4 Force distribution during picking up the ear

According to the analysis of the figure, the corn harvester rotates the corn straw in the direction perpendicular to the picking roller during the picking process, and this process occurs during the process of the stem passing the stem roller.

2.3 Power calculation of the picking roller

The power consumption of the picking process consists of two parts, on the one hand which is the power W_1 consumed by the picking roll pulling down the corn stalk, on the other hand which is the power consumed by the picking roll to remove the ear. The total power consumed by w is as shown in Equation 1-5.

$$W = W_1 + W_2 = \frac{\pi^2}{60^2} (m_1 + m_2) D^2 n^2 \cos \alpha + \frac{\pi^2}{60^2} (m_1 + m_2) D n t_1 \cos \alpha + \frac{\pi^2}{60^2} D^2 n^2 m_2 \quad (5)$$

In the middle: t_1 -Time of action of each force, s

m_1 -Stem quality, kg

m_2 -Ear quality, kg

D -The diameter of the root of the picking roller, m

n -Speed of picking roller, m/s

α -Picking roll tilt angle,

It can be known from the above formula that the power required for the picking roller to pull down the corn stalk is proportional to the quality of the corn ear, and is proportional to the diameter of the root circle of the picking roller; and is proportional to the square of the root diameter of the picking roll. According to statistics, the average power consumption of a pair of picking rolls is 1. 1-1. 25kw, and the actual power consumption of the picking rolls P_2 is 7. 5~9kw. The radial dimension of the picking roll is determined by Equation 1-6.

$$\frac{d_g - \delta}{1 - \frac{1}{\sqrt{1 + \mu_g^2}}} \geq D \geq \frac{d_j - \delta}{1 - \frac{1}{\sqrt{1 + \mu_j^2}}} \quad (6)$$

In the middle: d_g -Side rod diameter connected to corn fruit

d_j - Corn stem diameter

δ -The size of the gap between the two picking rolls in the same set of picking rolls

μ_g and μ_j -Grab coefficient of pair of picking rolls on corn fruit and corn stalk

According to experience, the diameter of the picking roller is too large to damage the ear. In this design, the diameter is 75mm.

3. Selection of hydraulic motor

3.1 Calculation of the power of the chain

The chain is mainly used to introduce the plant in front of it into the picking roller as soon as possible. Therefore, if the speed of the chain is too slow during operation, the plant may be blocked and accumulated, and the harvesting operation may be interrupted in severe cases; If the chain speed is too fast, it will not only lead to an increase in power consumption, but also an increase in the vibration of the header and blockage of the plant. The power calculation of the chain is as shown in Equation 1-7.

$$P_1 = \frac{nT}{9550} \quad (7)$$

In the middle: n -Dial the rated speed of the chain, take 180r/min
torque takes 15nm

The power of the chain is 0.28kw

3.2 Motor selection

Total power required for picking equipment:

$$P = P_1 + P_2, \quad P = P_1 + P_2 = 0.28 + 7.5 = 7.78$$

It is known that the speed of the picking roller motor is 524 rpm, and the hydraulic motor of the picking device is selected from the US White Cycloid Motor WS80. The main parameters are shown in the table1, so the flow rate of the motor is as shown in Equation 1-8.

$$Q = \frac{q_0 n}{60} \quad (8)$$

In the middle: q_0 -Motor displacement, 713cc/r.

n -Motor speed, 524rpm.

Calculated: $Q = 6.22 \text{ L / min.}$ Meet the design requirements of the picking device power.

Table 1 main parameters of the hydraulic motor

name	model	Displacement cc/r	Flow L/min	Set traffic L/min	Set pressure bar
Hydraulic motor	WS80	713	79	138	210

4. Conclusions

This paper analyzes and studies the picking device to find out the reason why the loss rate is too high. The new picking roller is designed and the hydraulic motor model is determined. We have determined the optimal picking roller parameters through design and analysis.

- (1) The speed of the picking roll was 836 rpm.
- (2) The angle of the picking roller is 35°
- (3) The radial dimension of the picking roll is 75 mm.
- (4) The model of the hydraulic motor is the US White Cycloid Motor WS80

Acknowledgement

This work was financially supported by the Shandong Province, the major project of science and technology (item number: 2015ZDZX10001) "the development and industrialization demonstration of intelligent corn combine harvester" .

References

- [1] Zhang Liping, Li Qizhen. Experiment on the speed and power consumption of bionic ear of bionic corn ear device[J]. Transactions of the Chinese Society of Agricultural Engineering, 2015, 31(19): 9-14.
- [2] Zhang Hao. Optimization and simulation of 4YZ-3 corn combine harvester picking device [D]. Shandong University of Technology, 2015
- [3] Jin Jin, He Junlin, Chen Zhi, Liang Xiaojun. Design and Experiment of Corn Picking Roll Test Bench[J]. Transactions of the Chinese Society of Agricultural Machinery, 2007(11):48-51.
- [4] Wang Chong. Research and development of a new type of corn cutting platform based on image recognition[D]. University of Jinan, 2017.
- [5] Zhang Dong. Design and implementation of oil peony fruit picking device [D]. Beijing Forestry University, 2016.
- [6] Yan Hongyu. Working Mechanism and Experimental Study of Key Components of Vertical Roll Corn Harvester [D]. Jilin University, 2009.