

## Design of Separation and Transportation Device for Sorghum Harvester

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**Abstract:** Sorghum is an important cash crop in northern China. The grain of sorghum can be eaten and brewed, and the straw can be used for roofing and crushing fertilizer fields. The existing agricultural machinery can only separate and pack grain and straw, and shredding and fertilizing of straw, it can not satisfy other production and life based on the premise of complete straw. Therefore, according to the characteristics of sorghum straw and the working mode of existing sorghum harvester, a sorghum harvester separation and transportation device is designed according to the principle of maximum utilization rate and diversification of crops. After meeting the needs of harvesting and separation, the function of directly producing sorghum stalk is added for production and life, and sorghum stalk can also be decomposed by existing grinding technology to ferment fertilizer.

### 1. Introduction

Sorghum is one of the earliest cereal crops cultivated in China. The main planting type in China is medium and high straw with stem height of about 2 m. Sorghum has a wide range of adaptability. It can be planted in arid hills and barren mountainous areas<sup>[1-3]</sup>. Therefore, it is an important cash crop in the north of China with less precipitation. The sorghum grains harvested by the tractor can be eaten as coarse grains. Now they are the main raw materials of famous liquors such as Maotai and Fenjiu. They can also be used as Chinese medicinal materials for disease treatment and prevention. There are many uses of sorghum straw: straw feed: straw energy building materials, light industry and prevention of raw materials straw matrix: at the present stage of handicraft, domestic sorghum straw is still in the use of farmers themselves, it is difficult to achieve industrial scale, can not play a good role in the use of sorghum straw. And domestic sorghum harvester after harvesting, sorghum straw or crushed in-situ fertilizer, can not be separated after the complete preservation of straw to achieve the purpose of secondary utilization. There are already wheat straw crafts on the market: jewelry boxes, water cups, toothbrushes and so on<sup>[4-7]</sup>. However, there are few sorghum straw crafts or other uses. Therefore, this design focuses on sorghum straw separation and overall preservation in order to develop the secondary utilization of straw.

### 2. Structure and Working Principle of Straw Separation and Transportation Device

The design of straw separation and transportation part adopts the box fixed structure, and the steel plate welding is used to provide support, so that other mechanisms can run smoothly. Cutting and feeding device harvest sorghum stalks and work together with collecting and transporting device to transport the cut sorghum to L-type transporting device. As the device continues to convey backwards, when reaching the highest point of the device, the stalk cutting device moves downward to cut, while the cutter slides backwards to transport sorghum fruits to the device, and finally to the back collection box through the device. The stalk part is laid flat in the field with the movement of the device.

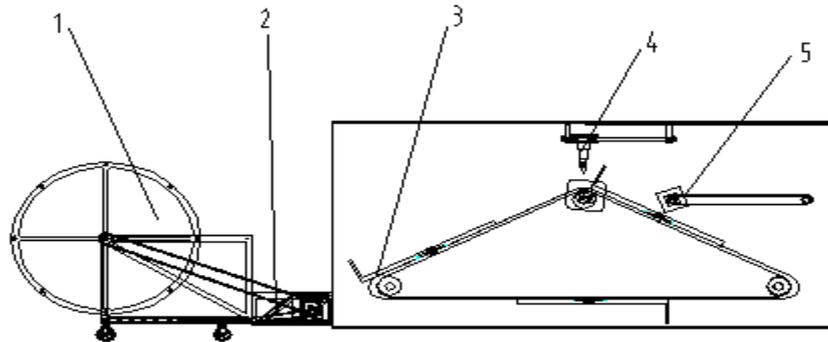


Fig. 1 Sorghum separation transport map

### 3. Key Components

#### 3.1 Frame Structure.

The forward direction is the reference direction, the thickness of the left supporting plate is 10 mm, and the through holes of two motors are reserved, its diameter is 80 mm. There are three fixed axes in the corresponding position, Axis diameter is 80mm. The data of the fixed axle of the right supporting plate is consistent with that of the left supporting plate, and the positions correspond to each other, and no through holes are reserved.

#### 3.2 Design of Transport Belt.

Flat belt drive is simple and efficient, so the belt is designed with flat belt. The thickness of the belt is 30mm, every 2000mm, with a hole of 50mm, which is used to fix the conveyor plate, and an end hole of 60mm is left inside the belt of 50mm through hole, so that the nut can be in the belt, reducing the impact of the fixed bolt on the motor drive shaft and sleeve, and preventing unnecessary faults.

#### 3.3 Selection of Belt Motor for Transportation.

Assuming that the transport belt is loaded with sorghum with a total mass of 40 kg, the friction coefficient between the belt and sleeve and the transmission shaft is 0.5, calculated according to the maximum estimation method, the friction force  $F_{\text{resistance}} = F \cdot \mu_s = (40 \cdot 9.8) \cdot 0.8 = 313.6\text{N}$ , ( $g=9.8\text{m/s}^2$ ), the maximum speed of ordinary flat belt transmission is 25 m/s, the design speed is 20 m/s, and  $V=20\text{ m/s}$  are calculated. According to the formula of motor power calculation ( $\eta=0.8$ ), according to the calculation results, after looking up the table, it can be seen that the selected motor model is Y315M-2.

#### 3.4 Design of Transport Plate.

The length, width and thickness of the transport plate are 1600 mm, 1185 mm and 40 mm. At one end of the transport plate, there is a baffle with a height of 200 mm to prevent sorghum from sliding from the rear of the movement during transportation. There is a hole of 10 mm in the distance of 450 mm and 700 mm from the front of the conveyor plate, which is fixed to the conveyor belt by rods, it ensures that no slippage occurs in the subsequent cutting and separation process.

#### 3.5 Hydraulic Separation of Straw.

Hydraulic rod pushes the cutter downward, cuts the straw, separates the sorghum spike and straw, and then moves the sorghum spike to the conveyor belt through the longitudinal movement of the cutter. The straw remains on the conveyor board. Through the follow-up transport action, it enters the collection box of straw to facilitate later use.

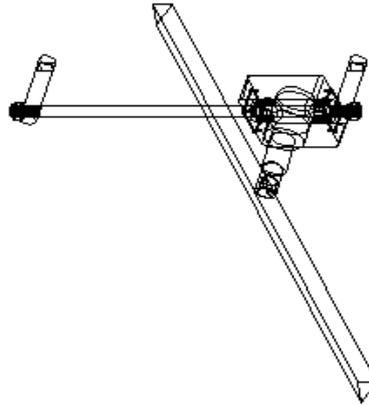


Fig. 2 Separation part of sorghum

### 3.6 Gear Pump.

The pump body only provides a shear force, it also needs to be slipped in the longitudinal direction, so the gear pump with simple structure, convenient manufacture, low cost, affordable price, light weight and small working volume is selected. According to the design requirements, the inner diameter of the pump body is 40mm, the working elongation  $H = 300\text{mm}$ , and  $A = \pi r^2 = 3.14 * 20 * 20 = 1256 \text{ mm}^2$ . It needs cutting in 4s, so hydraulic flow  $Q = V / T = 0.3768/4 = 0.0942\text{L/s} = 5.562\text{L/min}$ ; formulate shear force  $F = 700\text{N}$ , blade and sorghum contact area  $s = 0.05\text{m}^2$ , then gear pump type chooses KCB-18.3 and motor type is Y90L-4.

### 3.7 Design of Cover.

The cover is 93mm long, 50mm wide and 5mm thick. there is a sliding hole of 30mm in the center by cooperating with the clearance of the guide rail, it can prevent the driving cutting part from entering the dust, and also prevents the liquid from entering the material at the hydraulic end. Each of the four corners has a giant orifice with a diameter of 5 mm, which is fixed on the drive housing by a screw. it not only has a good optimization of the appearance of the mechanism, but also brings convenience to the later maintenance work.

### 3.8 Design of Guide Wheel.

In agricultural machinery equipment, the guide wheel mainly meets the following four requirements: reduce the resistance and slip phenomenon in the course of walking, and give full play to the working moment; In the course of walking, the subsidence of the mechanism decreases and the trafficability is enhanced. Facing different travel speed and working road surface, the mechanism can be well adapted, and the harvesting and transmission parts of the agricultural machinery can have good stability.

The fixing frame is made of 5 mm steel. The radius of the chamfered circle at the bending point is R10 mm. The diameter of the through hole butted with the support frame and the fixed through hole connecting the fixing frame with Taoism are both 12 mm. The surface contacted with the support is processed into a round end, which can prevent accidental injury in life. The bracket is designed as "U" type. It is connected with the fixing bracket through the diameter of 6 hexagonal bolts and sleeves to ensure that the free steering of the wheel is not affected while the bracket is fixed. Through the combination of fixed shaft and nut, the wheel is fixed on the axis, making it move around the axis in a circle. The "U" bracket also peel off the large soil on the wheel to reduce wear and tear in the actual process.

### 3.9 Selection of Cutting Blades.

The cutter angle is 21 degrees. the cutter have sharpness at 21 degrees, and it can also maintain the durability of the cutter. In addition, because the plant itself contains silicic acid and some gravel, they have abrasive wear on the tool, it will be blunt for a long time. Therefore, the cutter should also

have good abrasiveness.

In the process of using, both ends of the cutter are designed with a relatively long shaft and threaded on the outer end. The cutter is fixed to the corresponding tool holder through the nut on figure 3.2 and another nut. But the nut shown in Figure 3.2 rotates through the thread into the inner end of the thread. At this time, the axis is not threaded, and the nut can move freely in the axial direction. In order to facilitate the replacement of the tool, a spring is added to the distance between the nut and the blade shown in figure 3.2. When replacing, the tool can be removed from the tool holder by unloading the nuts fixed at both ends of the tool holder and extruding the tool to one end.

#### **4. Conclusion**

(1) A sorghum harvester separation and transportation device was designed, including controller, straw conveying device, spike conveying device and stem cutting device.

(2) Straw conveyor includes straw conveyor belt driven by the first power device, spike conveyor includes spike conveyor belt driven by the second power device, and stalk cutting device includes installation block and the first hydraulic power device, which provides a sorghum harvester capable of keeping straw intact during sorghum harvesting.

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