

Big ginger harvester design based on tractor

Qiu Zhenghai*

Shandong Institute of Agricultural Engineering, Qingdao, China

*Corresponding author

Abstract: On the basis of the reference and study of the current different ginger harvesting machinery related materials, this design constantly innovates and improves the existing technical scheme, combining the function of grain removal and mining. At the same time, through the use of various kinds of horsepower power machinery, can avoid the idle of power machinery, improve production efficiency, reduce production costs. During the design process, 3 D modeling was performed using SOLIDWORKS software in order to facilitate better observation and understanding of the relationships between various elements to obtain the best scheme. Through three-dimensional modeling, the coordination and movement between various components can be understood more intuitively, which provides a more scientific and accurate basis for the design. In the design, the design and calculation of the suspension frame, blade and excavation shovel are mainly carried out, which is also the focus and difficulty of the design. Through the calculation and design of these components, we can ensure the design of reliability and stability in practical applications. At the same time, the belt drive is also calculated and the design and calculation of the blade are completed, which can ensure that the design has better performance and effect in practical application. Finally, complete the overall configuration plan and assembly. The overall configuration plan can better understand the overall structure of your design and the relationship between the various components, providing a more scientific basis for the design implementation.

Key Words: Ginger, the harvester, except for the grain

1. Introduction

As an important economic crop, large ginger is widely planted in China. With the advancement of agricultural modernization and the gradual increase of labor expenditure, the traditional manual harvesting methods that are not enough to meet the needs of contemporary agriculture are gradually phased out. Therefore, further research on the big ginger harvester is needed, which is crucial to improve agricultural production efficiency and reduce labor costs, and can improve farmers' harvest and reduce the amount of labor.

In recent years, although the level of agricultural mechanization in China has been significantly improved, but the mechanization level in the ginger harvest link is still low ^[1]. The study of big ginger harvester can not only help to improve the agricultural mechanization system in China, but also improve the level of agricultural production mechanization. The research of big ginger harvester involves many aspects such as the design, manufacturing and control of agricultural machinery. Through the research of the big ginger harvester, to promote the development of the research and industrialization of agricultural related science and technology, and enhance the comprehensive strength of China's agricultural machinery. With the

change of China's rural industrial structure, the safe, economical and environmentally friendly agricultural production mode has gradually formed a development trend. The development of big ginger harvester can promote the reform of rural production mode, and promote the mechanization and modernization of rural industry development ^[2]. Through the research and development and use of ginger harvester, the labor intensity of farmers can be reduced and farmers' land efficiency can be improved, thus promoting the healthy development of agriculture and rural prosperity.

The research of big ginger harvester has received more attention and progress in China, especially in improving harvest efficiency and reducing labor cost. Internationally, because big ginger is not the main crop, so the relevant research and development is relatively few. As China advances in the mechanization of rice harvesting, more innovations and improvements may emerge in the future, and may also provide lessons for the mechanized harvesting of special crops in other countries.



Figure 1 The harvester on the market

High agricultural production efficiency, ginger harvest is a labor-intensive process, the traditional artificial harvest method is low efficiency, and labor intensity. One of the purposes of the ginger harvester is to improve the harvest efficiency, reduce the manpower demand, so as to improve the overall agricultural production efficiency. Promoting agricultural modernization, agricultural modernization is the key to realize the sustainable development of national agriculture [3]. The study of big ginger harvester is an important step to promote agricultural mechanization, automation and intelligence, which is helpful to realize the modernization of agricultural production. To ensure food security and the quality of agricultural products, efficient harvesters can reduce crop losses in the harvest process and ensure food security. At the same time, the mechanized operation can reduce the impurities mixed in the manual operation, improve the quality of agricultural products. Support the adjustment of agricultural industrial structure. With the continuous adjustment of agricultural industrial structure, the study of big ginger harvester is helpful to optimize the layout of agricultural production and promote the rational allocation of agricultural resources. Enhancing the international competitiveness, improving the efficiency and quality of agricultural production is the key to enhance the international competitiveness of agricultural products [4]. The research and application of ginger harvester is helpful to enhance the international

competitiveness of Chinese ginger industry.

This paper designs a simple structure and can work with the tractor big ginger harvester, which can adapt to a variety of working environment, the production cost is lower than the average market level. It can reduce the economic pressure of farmers in the purchase process, reduce the input cost of farmers, improve the efficiency of ginger, reduce the labor degree and working time, and provide a powerful choice. In the process of this design, not only learned from mechanical principles, mechanical design, material mechanics and other related knowledge, but also such as agricultural machinery, intelligent agriculture and other books specifically explaining agriculture. The ginger harvester consists of a cutting device and various components of the [5]. The limit wheel can adjust the depth of the shovel, while the height of the cutter does not use the limit wheel, but the height adjustment rod device is selected to control the height of the cutter, so that the machine can adapt to different heights and different kinds of plant harvest.

2. Big ginger growing environment and harvester appliance selection

The growing environment of the big ginger

Plant height: 0.5- -1 m; rhizome hypertrophy, many branches, vigorous development, aromatic and spicy [6]. The leaves are large and thick and are dark green. Each plant usually has 8-12 branches, many reaching 15 or more, and these branches are sparsely organized. The rhizomes are large and contain fewer ginger balls. Ginger balls are full, mainly in a single layer, few and sparse. Leaf lanceolate or linear, 15-30 cm long, 2-2.5 cm wide, hairless, sless, 2-4 mm long.



Figure 2 Characteristics of ginger ginger

Damage rate and ginger leakage rate of large ginger:

Damage: damage is a term used to describe damaged ginger pieces during harvest. Generally, the main cause of damage is that the machine is not able to meet the requirements of the harvesting of ginger; artificial damage from subsequent artificial harvesting is also considered a contributing factor, and the damage rate usually meets the production target. Choose the appropriate harvest time. The harvest time of the big ginger should be done after the growth period of the plant ends and the ground part begins to turn yellow. This can reduce the skin damage and wounds on the surface of the ginger cubes. Use the right tools, when the harvest of ginger, should make the cutter sharper, avoid the use of blunt tools to damage the ginger when cutting ginger. At the same time, the digging shovel of ginger should be blunt to avoid unnecessary damage to reduce damage. Take light, after the harvest of the ginger should be light put light, avoid beating or squeezing, try to maintain the integrity of the ginger. **Timely treatment:** the harvested ginger should be cleaned, dried or stored in time to avoid exposure to the sun or humid environment for a long time to reduce decay and damage.

Leak ginger: leak ginger refers to the unharvested part of the ground after the ginger is harvested. The main reason for missing the ginger is that the digging shovel on the excavator does not follow the depth and angle specification of the soil when harvesting the ginger. This will increase the intensity of the work that subsequent people handle, and increase

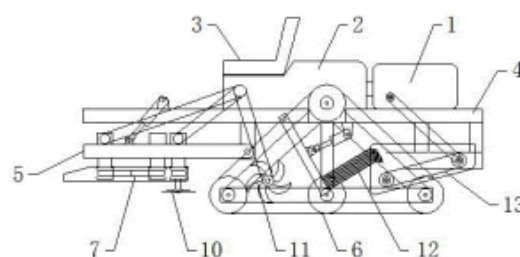
the rate of harvest damage. The proportion of ginger leakage rate should also achieve a satisfactory effect, generally less than 2%. When harvesting ginger, make sure that the harvest depth is moderate, not too deep or too shallow. Too deep will lead to fragile ginger pieces, too shallow is easy to leak ginger.

Depth and width of the shovel: The depth and width of the shovel must meet specific criteria (depth about 30 cm and width about 40 cm) to ensure that all ginger can be dug out. If the excavation depth and width are not enough, the ginger block will be destroyed or even leaked out.

Selection of the protocol appliances

A01D27 Harvest principle

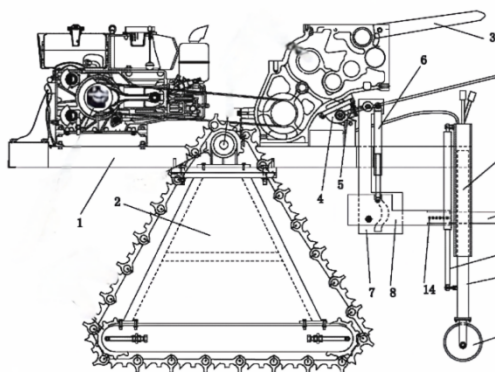
The left side of the diesel engine on the main frame is connected with the gearbox, the belt and the output end of the engine is connected with the sieve filter, the lower end surface of the main frame is connected with the secondary lifting frame, and the soil separator is connected with the right side, and the conveying tooth on the right side of the conveyor tooth is located above the sieve filter, the cutter, the gathering mechanism and the soil separator are connected with the output end of the front side of the transmission through the belt. When working, the diesel engine is used to drive the gearbox operation, and then drives the gathering mechanism, side transport mechanism, cutting machine and soil sieve device to run. The operation is simple, low workload, high work efficiency and good use effect.



1 Diesel engine 2. Transmission 3. Operating chair 4. main frame 5. secondary lifting frame 6. Walking mechanism 7. Gathering mechanism cutting machine 10.11. soil separator 12. conveying gear

A01D1 harvester principle

The vibration element is connected to the vibrating knife holder through a vibration connecting rod. Then, the vibration generated by the vibrating element is transmitted to the vibrating knife. The vibrator makes the roots of the large ginger growing in the soil become loose from the soil and separate from the soil. This enables timely and concentrated harvesting of ginger, resulting in an efficient mechanical harvesting process. Realize the mechanized harvest operation, high work efficiency, save time and effort.



1.Rack 2. walking frame 201. track 3. armrest 4. Vibration components 5. Vibration connecting rod 6. second power device 7. vibration tool holder 8. sliding frame 81. hinge point 9. vibration knife 91. T. knife tooth 10. slide rail 11. third power device 12. sliding rod 13. walking wheel 14. adjusting installation hole 15. arc groove

3. The overall scheme design of the big ginger harvester

Flow chart of the harvester design

First of all, the core functions and target market of the big ginger harvester need to be clearly defined. At the same time, the machine should adapt to different terrain and soil conditions, as well as improve harvest efficiency, reduce labor costs and other factors. Given these functional requirements, several possible solutions can be proposed.

Next, these proposed schemes need to be evaluated. The main criteria for the evaluation include feasibility, cost, efficiency, maintainability, and safety. If a solution does not perform well in these areas, new solutions need to be proposed.

After confirming that the scheme is feasible, the structural requirements of the machine need to be clarified. For example, the selection of the material types of each component, the connection mode between each structure, and the overall layout of the machine. Then according to these requirements, determine the mechanism and size of each component. The structures and dimensions involved are then evaluated. If it is not feasible, such as the size of the parts is too large, which affects the overall layout of the machinery, or the structural problems, resulting in the service life of the machinery is too short, all need to be restructured design.

After the feasible structure and ruler are determined, the detailed structural design and overall design can be carried out. This includes the detailed design of each component, the design of the connection mode, and the optimization of the overall layout. Need to ensure that the structure of the machine is stable, robust, and easy to maintain and operate.

Finally, the 3D simulation software (solid works).3D simulation software can be found before manufacturing, such as structural conflict and motion interference, so as to be modified and optimized in time.

After the 3D simulation is completed, it can be adjusted and optimized according to the simulation results, and the design scheme of the big ginger harvester can be finally determined.

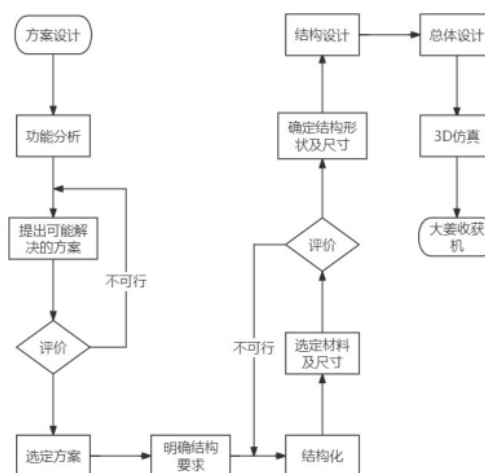


Figure 3 Design flow diagram

When the big ginger harvester is walking forward in the ginger ground, it is first

touched by the cutter of the ginger field mechanism, and it is removed. In order to prevent the cut ginger from affecting the follow-up work of the harvester, the support plate affects the tilt direction of the ginger, and it is transported to the side of the ridge to remove the obstacles for the digging shovel. As the harvester moves further, the depth limit wheel connected to the suspension rack will control the height of the machine. The same shovel attached to the suspension will enter the land with the power of the harvester. With further walking, the ginger will produce the surface, and the resulting soil will fall back to the surface through the gap in the middle of the shovel. The produced ginger will not fall on the ground, but through the subsequent belt drive to transport it to the harvest basket, to complete the harvest of the ginger.

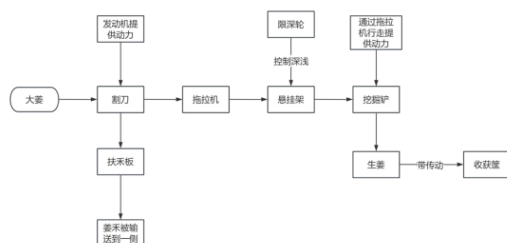
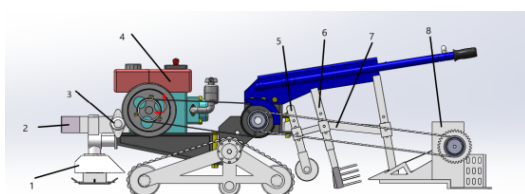


Figure 4 Work flow diagram



1. Harvest device 2. support board 3. transmission device 4. tractor 5. depth limit wheel 6. digging shovel 7. hanging device 8. Harvest basket

Figure5 Design product diagram

4 The main part of the big ginger harvester design

The ginger harvester is mainly powered by the engine. First, the blade rotates through the engine at high speed to cut Jiang He off and transmit it to the side of the road to prevent obstructing the work. Then use the excavation shovel to turn the ginger out of the ground, turn out the ground of the ginger through the belt drive into the harvest basket.

In addition to the grain part of the design

The removal mechanism includes the protective shell, blade and motor, etc. The protective shell is installed in front of the tractor through the screw, and powers the blade through the generator to make the blade work [7]. Then through the fu Wo organization will be sent to the side of the road, to complete the work [8].

Design of knives

In terms of size selection, the diameter of the blade should be close to the width of the ridge, so the protective shell and blade of the removal mechanism should be close to the width of the ridge, and the diameter is roughly 40CM. The distance between the blade and the ground should be determined according to the growth of the ginger, and keep 1-2CM with the ginger.

The cutting knife is equipped with fixed bolt holes, tightening bolts and cutting knife plate. The cutting plate is provided with a cutting knife fixing hole, and a gear-shaped blade is mounted on the cutting plate. The cutter is connected by fastening bolts so that the blades can be easily replaced and adjusted to meet different harvesting requirements.

Disc cutters usually come of two blade types: light blade and tooth blade. The tooth blade blade is mainly used for cutting rhizome crops. Compared with other blades, the design of the light blade blade is more concise, and its resistance in the cutter operation is relatively low, but its performance is not good, and the speed requirement is relatively high. Therefore, it is very important to choose a suitable blade to meet the needs of cutting operations. The tooth blade is better in terms of work efficiency and environmental adaptability. Therefore, given the uniqueness of ginger planting and the relatively low speed of the machine in this design, we chose the tooth blade as the main tool in this design.

In the process of work, due to the friction between the bottom of the blade and the squeezed Jiang He, the bottom of the blade wears out faster than the side. It is often rubbed, which makes the edge prone to rounded corners, which leads to wear. Therefore, in order to avoid these shortcomings, we must try to minimize them, which requires a new technology — cutting edge processing technique. It have found that some hard inclusions

derived from adsorbed mineral particles exist in cut soft (or elastic) materials. For example, most plant tissues contain crystals such as silicon oxide crystals, while on the plant surface, there are quartz particles that are the abrasive of the blade material [9]. These substances cause greater resistance to fragmentation, which causes the blade to slow down and even fail to be cut. We can use the friction between the cutting blade surface and the support parts and the cutting material. We can also use the change of the process to modify the shape of the blade mouth, which can achieve automatic grinding.

Considering the width of the tool of 40CM, the 45 steel was selected as the manufacturing material, and the chemical heat treatment technology of boron was used on its surface. The thickness of the boron permeable layer is 0.080.15 mm. This process helps to harden the blade. Experimental studies have shown that when the side and top of the blade are not so hard, the friction between Jiang He and the handle will exceed the wear speed of the top of the blade, thus delaying the formation of the rounded corners of the blade and enabling the tool to sharpen itself.

Guide support plate design

The guide plate is installed in the front of the tractor, and the main task is to complete the work of ginger ridge. In this design process, considering the agronomic requirements of ginger planting and its growth characteristics, it attaches great importance to the function and installation position of the guide support board. In order to ensure the working effect of the guide board, this design will guide the board placed on the side of the cutter, so as to better adapt to the growth characteristics of ginger. At the same time, in order to match the use of machinery, the guide support plate is designed into a mode with adjustable length, which can ensure its adaptability and flexibility. In terms of fixation, the front end of the guide plate is fixed by welding, so as to ensure the firmness and stability of the guide plate. In the rear of the design, considering the length adjustment, the bolt fixation is chosen to ensure the function that the length of the supporting plate can be adjusted. Such a design not only considers the functionality and practicality, but also

fully considers the integrity of the mechanical structure, which provides the design support for the ginger ridge cleaning work.

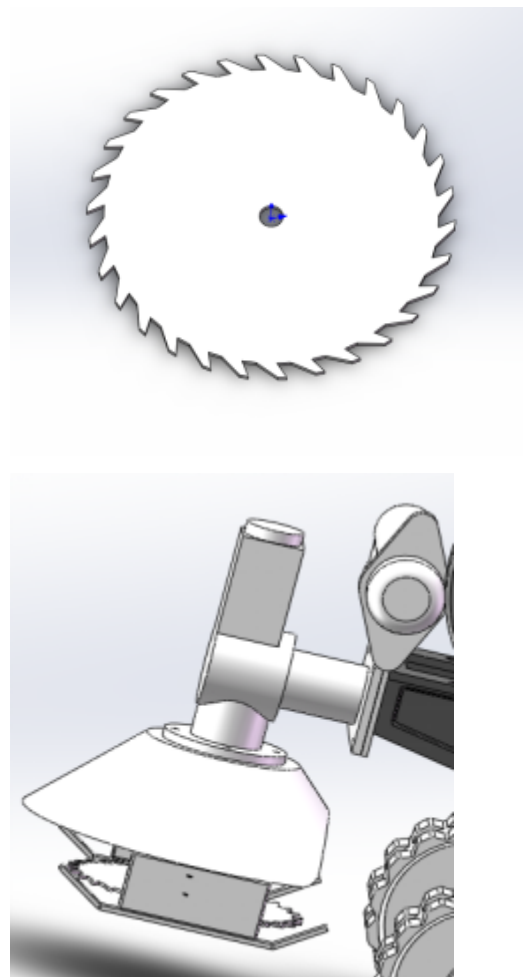


Figure 6 Blade blade and hoe section

The ginger section is designed

Mainly through the excavation shovel to produce ginger, through the tractor walking to power it, excavation shovel into the land. After it reached the specified depth, the ginger moved upward as the tractor walked, and the earth block flowed back to the surface because of the clearance of the excavation shovel. The ginger takes out of the land and then carries it to the harvest basket through the belt drive to realize the harvest of the ginger.

In terms of relevant dimensions, the shovel and the harvest basket also take the width of the ridge as the standard, but considering the depth of the shovel, the width of the shovel is 60-80CM. And the height of the basket is lower than the height of the excavation shovel transport. In terms of material, the excavation

shovel should also choose high strength and low alloy steel (HSLA) with high strength and easy to weld. This steel has good strength and corrosion resistance, but also has good welding performance [10]. Because of its high strength, it can reduce the weight of the structural parts, and it is not easy to crack and deform when welding, making the welding process easier.

In order to solve the problems of the current technology, we launched a large ginger pine soil shovel, which not only enhances the performance of large ginger in the harvest process, but also effectively reduces the risk of broken ginger pieces and ginger mother falling, thus improving the efficiency of harvest.

The design of the big ginger digging shovel has a V-shaped blade at the front. The two ends of the digging shovel are the protective devices of the ginger, which are fixed to a vertical fixed part respectively. The rear of the knife head is fixed to the sloping sloping tilt, and the rear of the flap is fixed to the horizontal loose board. The V-shaped blade is designed to help reduce the resistance into the soil, and the V-line blade is more stable. Both ends of the blade head have ginger guards to ensure that the ginger pieces in the soil are between the two ginger pieces and are protected, thus reducing the risk of breaking or falling due to the collision of the fixed parts. As it move further, ginger and soil will gradually rise in the inclined soil plate. In the process of ginger and soil rising, due to the joint action of force and gravity, ginger and soil will gradually separate, so as to achieve the effect of soil removal. The separated soil fell back to the ground under the design of the loose board, and the separation of the soil and the ginger was further separated by the design of the loose board, thus enhancing the soil removal effect of the ginger digging shovel.

According to the query, the downward inclined soil plate is preferably be from 40 to 70. Reasonable setting of the tilt Angle of the soil plate is conducive to the separation of soil and ginger in the movement of the soil plate. And ensure the integrity of the ginger cubes. Further, the ginger part is a straight line inclined upward along the plane of the blade. After the knife head and the fixed part enter the soil, the ginger pieces are

protected in the two protective ginger parts, which reduces the breakage of the ginger pieces caused by the collision of the fixing part and the ginger pieces caused by it. This is achieved by using ginger protective parts at both ends of the blade, which expands the harvesting space for ginger blocks in the soil. Further, the fixing portion further includes a depth adjusting bar with two or more threaded holes, which adjusts the depth of the shovel on the fixing sleeve through several bolt holes to adjust the fixing portion of the excavating shovel and expand its scope of use.

In the process of working, due to the complexity of the working environment, different materials have a great impact on the structure, stiffness and performance of the excavation shovel. There are great requirements for all aspects of the excavator shovel, in the process of excavation, the excavator shovel may collide with stones and other hard materials, thus damaging the opening of the shovel knife, which requires high requirements on the stiffness of the excavator shovel material. The toughness, structure, and performance of the excavation shovel have a large impact on material selection because the friction between the different materials is the same as the metals in the soil throughout the excavation. Since the excavation of the shovel has a greater variation in the stiffness requirement, measuring the entire area of the shovel shape that causes wear usually contributes significantly to the stiffness. During excavation, using a shovel to dig on the ground and touching hard objects such as stones may cause damage to the excavation shovel. Therefore, the material selection of excavator should not only have high toughness, but also have high stiffness requirements, so choose high strength and low alloy steel (HSLA).

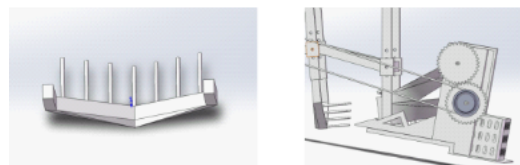


Figure 7 excavator and ginger part

The frame section is designed

The frame part is an important part of the harvester, which is to connect the tractor

with the ginger mechanism and other mechanical mechanism [11]. The quality of the frame shall be as light as possible to provide a simple overall structure while meeting the following specifications, less stress deformation, and strong vibration resistance. Structural design shall be appropriate to facilitate production, casting, welding, frame assembly and maintenance. Therefore, the design materials of the frame tend to choose Q235A (A3 steel), which has good cold bending performance, certain strength, high plasticity, toughness, welding, cold stamping and other characteristics.

In the shape design of the suspension frame, the suspension is connected with double-head bolts, one group is responsible for connecting the fixed suspension of the tractor, and the other group is responsible for adjusting the position of the suspension machinery. The devices such as the depth limit wheel fixed on both sides of the suspension frame and the excavation shovel can realize the upper and lower movement of the suspension to realize the adjustment and positioning of the excavation depth. In dimensional data, the width of the structure should be around 40CM (borrowed from the width of the ridge when most ginger harvest). The length should be 50-60CM, too short to form the arrangement of suspension machinery, which will lead to the interaction between the structure work, too long will lead to the harvesting mechanism to hinder the operation control of the tractor, which does not conform to the actual situation of the production scene.

The limit wheel is a device used to regulate the depth of the excavation shovel into the soil while ensuring the movement of the rack and power machinery in a straight horizontal path. Due to the direct contact between the limited depth wheel and the ground, the shear force at the double-bolt connection of the suspension can be minimized.

Two factors should be considered: first, no sliding between the soil because it will increase the excavation resistance and reduce the efficiency of the shovel; second, the height of the wheel should be reasonably limited. Excessive ground pressure can compacting the soil and affect the effect of digging loose soil and crushing soil during ginger mining.

The depth limit wheel is made of welded and rolled steel plate to adjust the nut on the top by adjusting the position of the rod, so as to change the depth of the depth limit wheel into the soil. The maximum vertical adjustment distance of this depth limit wheel is 150 mm. However, in order to avoid excessive pressure in some parts, the diameter of the limited depth wheel should be kept moderate to ensure its smooth rolling. For this purpose, this design uses a size of 220 mm.

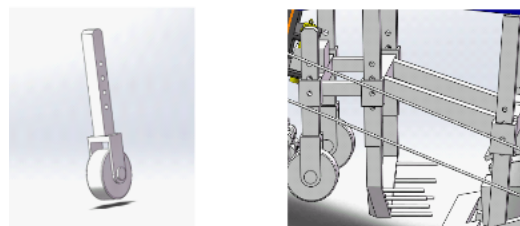


图 8 Related schematic diagram of the rack part

5 The main design and calculation of the big ginger harvester

Calculate the power P_{ca}

$$P_{ca} = K_A P$$

In the formula:

P_{ca} —— Calculate the power, KW;

K_A —— Work coefficient;

Through the data $K_A = 1.2$, And this design is the traction ginger harvester, and the transmission structure is simple, so the design calculation of the transmission part is only to meet the general tractor transmission requirements to achieve the wide use of ginger harvester, through access to the data can know that the rated power of

the walking tractor is generally $P=5KW$,

and $P_{ca}=6KW$.

Material selection for the belt wheel

In daily production, gray cast iron,

steel, aluminum alloy or engineering

plastics are often used in pulley materials.

When $V < 20m / S$, HT 150 is often

selected, HT 200 is often selected when

$20-30m / S$, when $35m / S$ diameter is

large and power is large, 35 steel and 40

steel are commonly used. Engineering

plastics for high-speed and low-power

use. When the batch is large, the die-cast

aluminum alloy or other alloy can be used.

According to the formula:

$$v = \frac{\pi d n}{60 \times 1000}$$

$v \approx 2m/S$, Because the speed is not

large, the manufacturing material with

the wheel should be HT 150.

6 Conclusions

Due to the simple structure, low power consumption, small volume, high operation efficiency and low damage rate, it greatly reduces the workload of farmers. At the same time, the device works together with the power equipment, and the power equipment is easy to dismantle and store, reducing the unnecessary waste of idle machinery in the subsequent seasons and ginger planting. The following conclusions are drawn from the design:

1. Triangle shovel is used in the ginger outlet device, which is simple in structure and easy to repair, and can reduce the manufacturing cost. And the triangular structure can enhance the strength and stiffness of the excavation shovel, and

reduce the probability of mechanical failure.

2. In order to prevent the chopped ginger seedlings from interfering with the walking ability of the power machinery and the excavation ability of the shovel, the removal device cleaned the ridges when cutting the ginger grass.

Reference

[1]Feng Qigao, Mao Hanping. The development status and countermeasures of agricultural mechanization in China [J]. Agricultural mechanization research, 110(2):4.DOI:10.3969/j.issn.1003-188X.110.02. 071.

[2]Liu Yuankun. Exploration and practice the "three changes" reform in rural areas [J]. Administrative management reform, 116(1):4.DOI:CNKI:SUN:XZGL.0.2016-01-01

[3]Xu Lingli. Research on the application Agricultural Engineering technology in Agricultural Modernization [J]. Modern Agriculture Research, 2022,28 (2): 3.

[4]Wang Yongde, Shang Jie, Zhao Jigang. Review of comparative studies on the international competitiveness of agricultural products [J]. Academic Exchange, 108(1):5.DOI:10.3969/j.issn.1000-8284.2008.028.

[5]Liu Hua, Zhang Jiulei, Zhang Zijun. Simulation design of ginger mining harvesting mechanism based on ProE [J]. Modern Agricultural equipment, 113(4):4.DOI:CNKI:SUN:GDLJ.0.2013-04-01

[6]Pei Yaping. SFE / SD-GC-MS analysis the aroma components of Shandong large yellow ginger essential oil [J]. Food Research and Development, 120,41(3):8.DOI:CNKI:SUN:SPYK.0.2020-03135.

[7]stratagem. Design and study of the lawler lawn mower [J]. 2017.

[8]Sun Shufa, Liu Jinhao, Ye Yu. Dynamics analysis of the transverse cutting mechanism of windbreak and sand-fixing grass squares [J]. China Desert, 111,31(5):1087-1092.DOI:10.3724/SP.J.1226.112.00439.

[9]Ma Wenlie, Liu Renxin, Yan Xuanzhou. Improved design of a small human rice harvester [J]. Journal of Jiangxi Agricultural University,

- 2004,26(6):3.DOI:doi:10.3969/j.issn.1000-2286.2004.06.032.
- [10]Zhang Binran. Advantages and application prospects of high-strength steel [J]. Win the Future, 2017 (13): 1.
- [11]Chen Key, Qin Haixin, Yang Wang. Simulation optimization of cassava block uprooted mechanism [J]. Agricultural Mechanization Research, 2015,37(7):5.DOI:10.3969/j.issn.1003-188X.2015.07. 010.
- [12]Yin Kaili, Wang Shaojiang. 4 JW-1 four-wheel drive self-propelled ginger harvester came out [J]. Rural New Technology, 2011,01(1):37-37.DOI:CNKI:SUN:NCXJ.0.2011-01-036.
- [13]Zhang Shixi. Study on the excavation mechanism and structure design of the water chestnut harvesting vessel [D]. Shaanxi University of Science and Technology, 2013.DOI:10.7666/d.Y2307877.
- [14]Ma Wenlie, Wang Qiang, Liu Renxin, et al. Design of the human grain cutter [J]. Agricultural mechanization in China, 2004(5):2.DOI: 10.396
- [15]Zhang Kai, Zhu Hongtao, Yang Quan, et al. Mechanical optimization method of geometric parameters of soil sampling head [J]. Journal of Nanjing University of Information Science and Technology (Natural Science Edition), 2012(5):430-436.DOI:10.3969/j.issn.1674-7070.2012.05.009.
- [16]Zhao Pingui. Complete machine design of laboratory coarse crushing jaw crusher [D]. Taiyuan University of Technology, 2012.DOI:10.7666/d.y2156355.
- [17]Wang Xujian. Full-automatic ginger harvester.2013[2024-05-08]. DOI:CN202998845 U.
- [18]Wang Shusen, Wang Shaojiang, Wei Jili. Four-wheel self-propelled type ginger harvester.2010[2024-05-08]. DOI:CN101627680 A.
- [19]Wei-Hua L I , Bo Z , Wei-Hai Z ,et al.Development of 4GJ1 Ginger Harvester[J].Agricultural Equipment & Vehicle Engineering, 2009.
- [20].Crawler type ginger harvester.2015[2024-05-08].
- [21]Zijun Z , Peihan Q , Chaozhi Z .Finite Element Analysis of Digging Shovel of Ginger

