Functional Structure Modeling and Assembly Practice of Ditching Fertilizer Based on Standardized Module Design

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Abstract. In the existing agricultural machinery field, the agricultural machinery is generally cumbersome, the transportation, disassembly and assembly, maintenance procedures are more complicated, and the functions are single, and the versatility is not good. This article combines the industrial design standardization and modularization ideas for the trenching fertilizer application machine. Model construction and assembly practice were carried out. The whole machine was built according to independent functions, and divided into racks, fertilisers, trenching assemblies, suspension systems, transmission systems, etc. Modeling of the rack, modeling of the fertilizer turntable, and plowing the modeling process is elaborated. By assembling the functional components and standard parts, the modular design idea can be reused and exchanged in the design of the trenching fertilizer machine. The relevant modules can form the final product through the arrangement and combination. The final assembly entity can be a variety of products, which can better meet the customer's customization needs; the repetitive use of similarity can make the whole product more convenient in manufacturing and maintenance, and the overall machine coordination and appearance are more beautiful.

1. Introduction

With the development of agriculture's demand for modernization, China has developed a variety of digging and fertilizing machinery, which is mainly used in soybean, rice, sugar cane and other crops, and generally adopts methods such as outer groove wheel type, scraper type and throwing type. The machine has its own supporting frame, trenching plough, fertilizer discharging mechanism, etc. Although their respective structures are relatively simple, they basically adopt functional structural design methods, lack of modular and standardized design ideas, and their fertilization process, function replacement, and parts maintenance. All need to be done manually, and fine control cannot be done [1].

Most of the ditching and fertilizing machines in foreign countries are large-scale machinery, which tends to be dedicated to special planes, but generally reflects the elements of standardized design. The CASE860 chain trencher and the T-1255 chain trencher developed by the American company have been equipped with more advanced devices, but can only achieve a single function of trenching [2]. The centrifugal spreader developed in Australia is relatively simple in structure and high in production
efficiency. However, it is not suitable for domestic use due to cost and environmental compatibility [3-6]. The ultrasonic sensor system developed by Saeys et al. is used in the ditching and fertilizing machine to automatically adjust the ditch depth [7-9].

With the increasing demands of the society for modern agriculture, under the limited land resources, it is impossible to achieve the cost-saving increase only by satisfying the existing fertilization technology, and it is necessary to carry out the development of agricultural machinery from the standardization and modularization. Designed to maximize cost and maintenance, functional interchange and other benefits.

The development of precision fertilization technology is inseparable from the development of standardized fertilization machinery. The new fertilization machinery should have the characteristics of simple structure, simple operation, saving input cost, improving use efficiency, etc., which is convenient for farmers to maintain and repair. The core components are rack and trenching plow. Body, fertilizer mechanism, etc. The fertilizer-discharging mechanism can replace the artificial fertilization and automatically apply a certain amount of fertilizer to the gum tree. With the continuous development of intelligent agricultural machinery, more and more intelligent agricultural machinery has entered the field to replace human-machine collaboration. The new fertilizing machinery will continue to develop along the direction of intelligence, continuously improve the level of precision fertilization technology, and promote the development of precision fertilization technology [10-14].

2. Functional Structure Modeling of Modular Ditch Fertilizer

Here, SolidWorks 2016 is used to model the three-dimensional solids of the trench fertilizing applicator, focusing on the modeling process of the rack, fertilizer turntable, deep trench plow and the control mechanism, and the structural design of the control mechanism to make it have multiple Angle adjustment function, which provides reference for researching standardized and modular fertilization technology.

2.1. Rack modeling

The rack is the basic part of the entire machine and serves to communicate with other systems. A fertilizing system, a hydraulic system, and a three-point suspension system are installed above the rack, and a trenching system is installed below. The modeling of the entire rack can be divided into the creation of the frame beam, the creation of a three-point suspension system, the creation of a fertilizer assembly, and the creation of a rear suspension.

The frame beam can be simply constructed as a plurality of square steel models, and the modeling process can be done with a stretched rectangular parallelepiped. Select the "Extruding Boss" command, select the upper reference plane as the reference plane, draw a rectangular sketch and define the required size. After exiting the sketch, enter the desired stretch length value to complete the creation of the square steel model. Use the same steps to draw other square steel models on the same datum plane. It is important to note that each time you draw an entity, you need to uncheck the "Merge Results", as shown in Figure 1.

![Figure 1. Supporting bracket model.](image)

Further improve the model, add stiffeners, and draw two support frame holders for the model, as shown in Figure 4. The modeling idea of the fixture still uses the "stretching boss" command to create a drum, and then the side of the adjacent square steel model is used as a reference plane, and the intermediate small round hole is drawn by stretching and cutting, and the small round hole is supplied to the bolt.

Then use the "mirror direction" command to select the symmetry plane "right-view datum plane" from the mirror face. Select the model to be the mirrored entity to create the support frame holder on the other side. The frame beam assembly is shown in Figure 2.
For the same reason, create another datum, as shown in Figure 3. Using the datum plane as the sketching plane, complete the sketching of the left lower dangling point of the three-point suspension system, and stretch the model of the left lower dangling point by the "stretching boss" command, and take the "right-view datum" as the mirror direction. The bottom right hanging point is generated by mirroring.

After completing the creation of each suspension point, the three-point suspension system is supplemented with the drawing of the reinforcing ribs. The final rendering is shown in Figure 4.

The fertilizer assembly mainly includes a hopper, a barrel fixing ring and a worm and a worm reducer base and a fixed ring. The modeling idea can be to first draw the base and the fixed ring of the worm gear reducer, and then draw the barrel fixed ring and the hopper.

The bottom plate of the reducer is a simple plate-shaped model, which can be drawn by a command of "stretching boss". The creation of the reference plane of the fixed ring of the reducer can be created by referring to the reference plane of the three-point suspension system, and the same stretching command can be drawn. Since the two-part model is relatively simple, its creation process is similar to the previous model creation process, and will not be described here.

Call the "stretch boss" command to draw a sketch of the closed part of the hopper. After exiting the sketch, enter the value of the stretch length. Use the "shell" command to enter the thickness of the shell and select the shell surface to perform the shelling process on the model just drawn, as shown in Figure 5.

Referring to the above process, after the entire rack is modeled, the effect diagram is shown in Figure 6.
2.2. Fertilizer turntable modeling

The fertilizer turntable is an important part of the fertilization system. The bottom is connected with the drive plate by bolts, and the drive wheel is rotated by the worm gear reducer to drive the fertilizer to rotate.

Call the Stretched Boss command, use the Top View Datum as the sketching plane, draw a circular outline and define the dimensions, and enter the stretch length value after exiting the sketch. Use the Shell command to shell the model you just created. Use the "Right-view datum" as the sketching plane to draw a right-angled triangle sketch, and use the "Rotate Boss" command to complete the rotation of the above sketch. Finally, create four threaded holes at the bottom of the model, call the Shaped Hole Wizard command, select the specifications of the desired hole, edit the hole position sketch, and complete the creation of the threaded hole. The effect diagram of the fertilizer turntable model is shown in Figure 7.

![Figure 7. Fertilizer model](image)

The drive plate is a key component for connecting the worm gear reducer and the fertilizer chassis. The structure is relatively simple. It can be simply viewed as consisting of a drum and a disc. The modeling idea can draw the drum model first, and draw on this basis. Out of the disc structure. The modeling process of the drive disc is mainly done by two commands: the tension boss and the stretch cut. As shown in Figure 8.

![Figure 8. Drive plate model](image)

2.3. Plow modeling

The deep groove plough is the core component of the trenching system. The upper two holes of the main shaft can be adjusted by the bolts and the frame beam holes to adjust the different positions, thereby adjusting the depth of the deep groove plough. The difficult part of modeling the deep trench plough model is the creation of two wings. The modeling idea of the model can use the two commands of “scan” + “stretch cut”.

Use the "Right-view datum" as the sketching plane to draw a sketch of the main shaft outline, and use the "Stretching Boss" command to stretch the boss symmetrically on both sides. Take the front end surface of the main shaft as the sketching plane, and combine the two commands of stretching and cutting to draw the small boss connected with the plow head. The effect diagram is shown in Fig. 9.

![Figure 9. Plow column creation renderings](image)

After the wing is created, a similar extension is created for the front end of the wing in a similar manner. Use the “mirror direction” command to mirror the wing and add stiffeners to the middle of the two wings to meet the stiffness design. The effect diagram is shown in Figure 10.
3. Functionalized module assembly practice
The composition of the trenching fertilizer applicator can be divided into four parts: the frame, the ditching system, the hydraulic system and the fertilizing system. The other standard parts are the parts in the standard parts library of the 3DSource parts library.

Create a new "Assembly", browse the components you need to insert, and insert the component into the assembly interface, as shown in Figure 11.

First assemble the rack and trench system. Insert the frame model and the deep groove plough model into the assembly interface, adding a "width" fit to the two models, limiting the three degrees of freedom of the X-axis movement, the Y-axis rotation, and the Z-axis rotation. Then, the rear side of the deep groove plough main shaft and the rear side of the inner beam of the frame are added with a "coincidence" fit to limit the two degrees of freedom of the Z-axis movement and the X-axis rotation. Finally, a "coaxial" fit is added to the upper hole of the slotted plough spindle and the middle beam hole of the frame to limit the movement of the Y-axis by one degree of freedom, and the cooperation between the frame and the deep groove plough is completed.

In the same way, the assembly of the small grooved plow, the grooved disc and the frame on the left and right sides is completed in turn, and finally the bolts and nuts of the target size are inserted into the frame and the trenching system from the 3DSource parts library, and the corresponding position is added. The six-degree-of-freedom constraint is completed, and the effect is shown in Figure 12.

4. Discussion
In the structural design process of the trenching fertiliser machine, based on the idea of standardized module design, we have independent functions for each part, with a uniform geometric connection interface and a unit of consistent input and output interfaces, and modular design, the results found the same kind of modules can be reused and exchanged in the product family. The arrangement of the relevant modules can form the final product. The final assembly entity is shown in Figure 13. Through the combined configuration of the modules, it is possible to create products with various requirements to meet the customization needs of customers; the reuse of similarities can make the entire product manufacturing and maintenance more convenient.

Figure 10. Wing creation rendering

Figure 11. Example of an assembly interface

Figure 12. Assembly renderings

Figure 13. Assembly machine
In order to replace a certain functional module to achieve quality or efficiency improvement, without changing the entire structure, only need to change the corresponding module, the workload will be significantly reduced, so modular design and application, is the industrial design ideas introducing an effective attempt to design the structure of the trenching fertiliser, the design and assembly practices show the following characteristics:

1. The structure is more reasonable. Due to the modular design, the internal structure of the trenching fertiliser machine is more reasonable and more scientific, so that the function of each component can be well played and the service life of the whole machine can be extended;

2. Maintenance is simpler. Each part of the trenching fertiliser application machine is a module. If there is a problem with the machine, it can be diagnosed quickly. It only needs to replace the corresponding module, and the operation is simple. It can be replaced without the need of professionals, which saves farmers time and effort!

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