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Chuanhua Yang, Ma Xu, Zhoufei Wang, Wenwu Yang, Xinglong Liao

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ChuanHua Yang [1,2*] , XuMa [1] , ZhouFei Wang [3] , WenWu Yang [1] XingLong Liao [1]

1 Key Laboratory of Key Technology on Agricultural Machine and Equipment (South China Agricultural University), Ministry of Education, Guangzhou Guangdong 510642, China
2 College of Mechanical Engineering, Jiamusi University, Jiamusi Heilongjiang 154007, China
3 Science College, South China Agricultural University
* Corresponding author, Address: College of Mechanical Engineering, Jiamusi University, Jiamusi Heilongjiang 154007, China Tel: +86-454-8618685,+86-18903643399 Email: chuanhua_yang@126.com

Abstract: The digital model of the laboratory bench parts of digging deep rootstalk crops were established through adopting the parametric model technology based on feature. The virtual assembly of the laboratory bench of digging deep rootstalk crops was done and the digital model of the laboratory bench parts of digging deep rootstalk crops was gained. The vibrospade, which is the key part of the laboratory bench of digging deep rootstalk crops was simulated and the movement parametric curves of spear on the vibrospade were obtained. The results show that the spear was accorded with design requirements. It is propitious to the deep rootstalk.

Key Words: Deep rootstalk crops, Parametric model, Virtual assembly, Simulation

1. INTRODUCTION

Started from the 1940s, many overseas countries, such as the United States, West Germany, Japan, France, Italy and other developed countries have developed many kinds of rhizome crops harvest machinery. For

example, they have already achieved the mechanized harvest of the long root crops（radish, beet and so on）and short root crops(potato , peanut , garlic , onion and so on), but have not reaped the crops which root depth is greater than 40cm. Our country, has introduced the excavation since the 1960s, which is mainly used to reap the short rhizome crops such as the peanut, potatoes, etc. in early days. As to the deep root crops, such as Radix Astragali, Radix Hedysari, skullcap, licorice, their harvest mainly on the artificially excavation. Research of the deep rhizome crops excavating machine started from 1980s, successively developed the model which is suitable for the rhizome that is smaller than 40cm, for example: Agricultural Experiment Station in Changzhi city in Shanxi Province developed 4SD-280-type vibrating root harvester, Heilongjiang provincial hydraulic research institute developed 4WZ-140-type, Weiyuan county of Gansu province introduced 4WG-120-type and so on; the model which is suitable for the rhizome that is bigger than 40cm, for example: agricultural research institute of Baicheng City, Jilin Province researched 4GKJ-11-type root tuber harvester, Agricultural Promotion Station in Weiyuan county, Gansu province developed 4YW-160-type rhizome crops excavator and so on. The design of these machines is primarily using the traditional design method, there are somewhat conservative dimension of product design, bigger product size, higher cost, longer design cycle, over-dependent on multiple rounds of physical prototypes trial, the level of the design constraints and other issues to raise. In addition, these machines have a single vibration, when carries on the deep earth excavation, needing overcome too big resistance, the power consumption is too large as well.

We used powerful CAD and CAE software – US PTC Corporation's Pro/E software for this machine to carry out parametric modeling, virtual assembly and other digitized designs, and has carried on the assembly interference testing, have realized the dynamic performance of pre-fabricated components, have predicted the product performance accurately , have reduced or avoided the physical prototype's trial manufacturing, enhanced a success rate of the design, so as to reduce the product's design development cycle ,reduce the cost , improve the design quality.

2.　THE DIGITIZED MODEL OF THE DEEP RHIZOME CROPS EXCAVATING EXPERIMENTAL PLATFORM.

Digital design technology is based on the product description of the digital platform, establishes the computer-based element of the digital product model and is used in the whole process of the product development,

to reduce or avoid the use of physical model of a product. Among them digital modeling is the basis of digital design, and provides the technology infrastructure for the future design analysis, simulation and so on.

2.1 The structure of the deep rhizome crops excavating organization

Before establishing experimental model of the deep rhizome crops excavating experiment platform and virtual assembly, we must analysis the structure of the deep rhizome crops excavating organization and define the relation between each spare part. Take the model 1WZ deep rhizome crops excavating test-bed as study object, it mainly includes traction frame 1, coulter 2, the pivot axis of the coulter vibrating frame 3, digging share motor 4, coulter vibrating frame 5, coulter driving motor 6, coulter eccentric vibratory governing mechanism 7, the frame 8, depth wheel governing mechanism 9, digging share eccentric vibratory governing mechanism 10, depth wheel 11, digging share vibratory suspender 12, digging share 13, the branch arm of digging share 14, the junction panel of knife arm 15 and digging share vibratory support axis 16, as shown in Figure 1. The whole model of the deep rhizome crops excavating experiment table which completes finally through the virtual assembly, as shown in Figure 2.
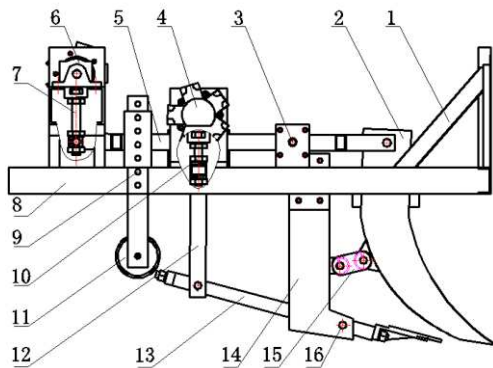

Fig.1 The structure of the 1WZ- type deep rhizome crops excavating test-bed
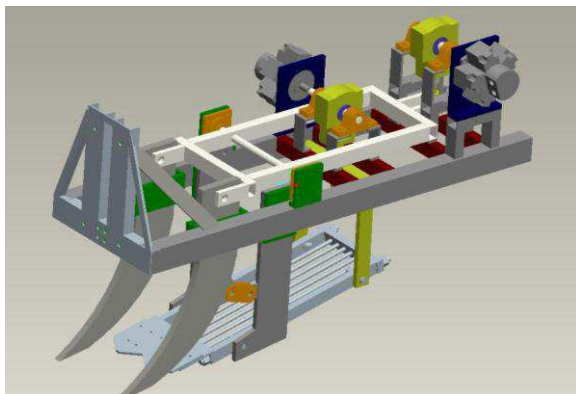
Fig.2 The digital element model of the 1WZ-type deep rhizome
crops excavating test-bed

There are two sets of lever system in this machine, coulter driving motor 6 and coulter vibrating frame 5 take the pivot axis of the coulter vibrating frame 3 as the pivot point driving the coulter 2 forms one set of the lever system, the active force arm is greater than the passive force arm, which makes the coulter 2 generates a greater vibration power in the approximate vertical direction, when the coulter driving motor 6 has smaller output power. The digging share motor 4 and digging share vibratory suspender 12 take the digging share vibratory support axis 16 as the pivot point driving digging share 13 forms the other set of the lever system, its active force arm is also bigger than the passive force arm, when the digging share motor 4 has smaller output power, which makes the point of the digging share 13 produces a greater vibration in the approximate vertical direction so as to achieve the saving power purpose.

2.2 Establishment of the parts entity model

As the design and development platform, using the Pro/Engineer software which 3-D engineering software is based on the technology of parametric feature driven and characteristic modeling, directly designs the parts of the deep rhizome crops excavating organization, establishes the entity model of the parts. For most of the components, they were finished by using the feature modeling methods that Pro/Engineer provides, such as stretching, rotating, scanning and mixing. In the modeling process, we must first determine the order of the characteristic, because the order of the characteristic will have tremendous influence on the model results. Next, we must simplify the type of the characteristic and notice the association problems between the characteristics, namely establish appropriate fathers

and sons relations characteristic. After establishing the entity model of the parts, if it is found that the parts cannot meet design requirements, we may amend the characteristic parameters of the parts to modify the design of the parts, which greatly improve the efficiency of the design.

2.3 Virtual assembly of the experimental platform

Virtual Assembly (called VA for short) uses computer tools to realize the physical, without product or support process, to carry on or assist to process the related assembly project decision-making through the analysis, the pre-modeling, the visualization, the date expresses etc.

Total parts of the deep rhizome crops excavating experimental table, such as traction frame, coulter, driving motor, coulter vibrating frame, governing mechanism of the coulter vibrating frame, the adjusting device of the bottom shovel vibrating frame, the bottom shovel vibrating frame, the bottom frame, the plow arm, all the static connection parts to carry on the fixed assembly. Namely in Pro/E using automatic, matching, alignment, insert, coordinate, tangency, online dot and other constraint types in "the module laying unit" to place the components with the placed constrains, as shown in Figure 3; And the active connection part in which to carry on the connection assembly. Namely in Pro/E using pin joint, slide bar, cylinder, flat and other constraint types in the "connect" unit in the "module laying" to place the components with the link constraints, as shown in Figure 4.
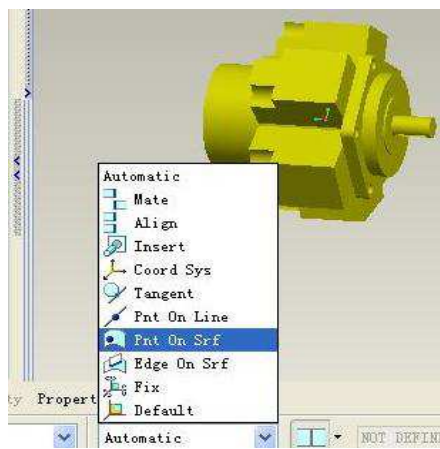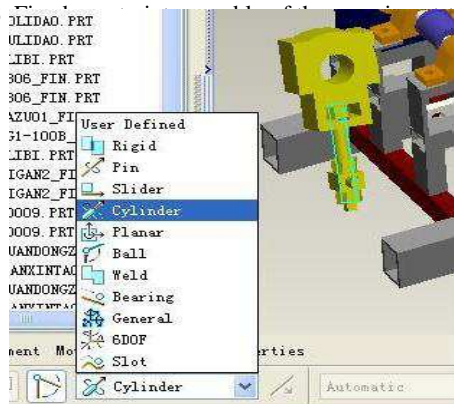

Fig.3 Fixed constrains assembly of the excavating table components

Fig.4   Linking   constraint   assembly   of   the   experiment-table

3. SIMULATION ANALYSIS OF SHOVEL KEY COMPONENTS

3.1 Motion analysis of the shovel point simulation model

After establishing the virtual prototype of the experimental table, we can measure the diversity parameters of different point in the bottom shovel, in the real situation to obtain the diversity displacement, velocity and acceleration change situation on the bottom shovel, through an analysis of the measure curve, to check whether the design is reasonable. In this case, the shovel point is the key force bearing point on the bottom shovel, so we must measure the displacement curve, the velocity curve and the acceleration curve for the analysis. The measure results of the horizontal movement direction of the bottom shovel tip are shown in the Figure 5, the measure results of the vertical movement direction of the bottom shovel tip is shown in Figure 6.

3.2 Analysis of the shovel tip simulation results

Known as Figure 8, shovel tip's position in horizontal direction approximately is between 185.45mm~-184.87mm , horizontal displacement amount is 0.58mm. Known as Figure 9, shovel point's position in vertical direction approximately is between -638.90mm~-634.42mm, vertical displacement amount is 4.48mm. Horizontal and vertical directions' displacement quantity conforms to the design requirements of the vibration amplitude, the vibration of this way helps to cut the soil into pieces.
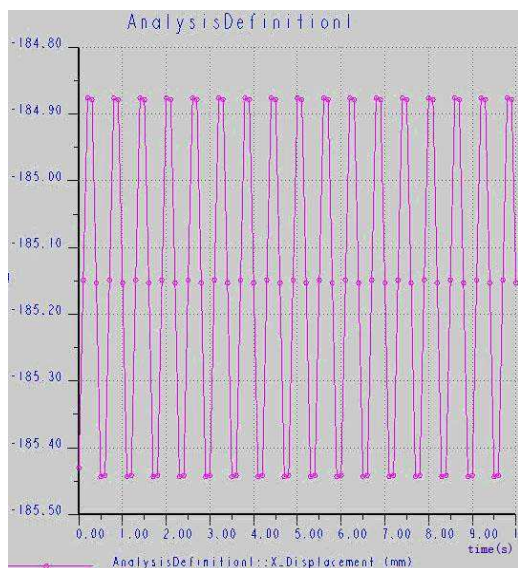
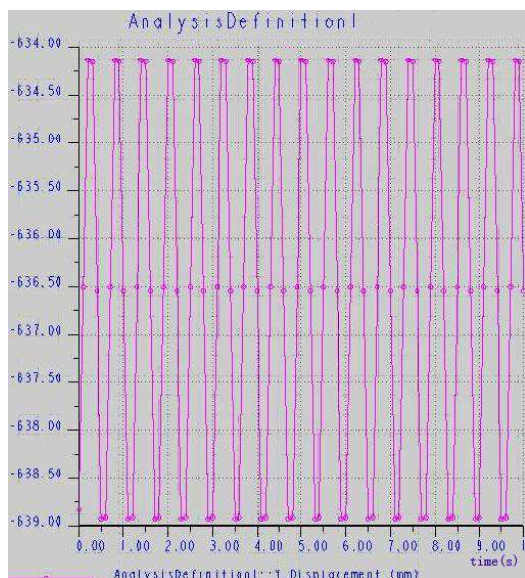Fig.5 Horizontal displacement of the bottom shovel tip

Fig.6 Vertical displacement of the bottom shovel tip

Likewise, shovel tip's horizontal direction speed is between ±3.4mm/sec, shovel tip's vertical direction speed is between ±28mm/sec. These values meet the initially design requirements of the vibration frequency, shovel point's horizontal direction acceleration is approximately between $31\sim29mm/sec^2$, shovel tip's vertical direction acceleration is approximately between $250\sim260mm/sec^2$, although the acceleration in vertical direction is

big, it is within the design range. Anyway, the kinematics simulation results of the bottom shovel tip are in accordance with the theory movement analysis, which meet the design requirements.

4. CONCLUSION

(1)Under the support of the Pro/E platform, established the digital entity model of the deep rhizome crops excavating experiment table' parts, in the modeling process, the components dynamic design has been realized, the development efficiency has been enhanced, the virtual assembly of the parts and the whole machine of the experimental platform have been completed, the assembling-possibility has been improved.

(2) The simulation of the bottom shovel's vibration which is the key part of the deep rhizome crops excavating experiment table has been completed, the analysis of the shovel point's motion parameter curve shows that vibration of the bottom shovel tip is in the range of the design requirements, shovel tip's motion law is in accordance with the theory analysis, meet the design requirements, which is helpful to the deep rhizome crops excavation.

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