Analysis and Simulation of Gradeability of Orchard Operation Platform Based on ADAMS

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Abstract: In view of the instability of the orchard machinery in the hilly terrain in China, this paper takes a crawler orchard operation platform as the research object. On the basis of mechanical design and theoretical analysis, the model is created by Solidworks and imported into ADAMS. It performs kinematics simulation and obtains experimental data of the machine running on a slope with a certain gradient. The simulation experiment sets the slope angle between 0° and 35°, and displays the climbing ability and working state of the orchard work platform by changing the driving force of the engine. The simulation results show that the orchard work platform designed in this paper can be used to carry out the work in the hilly area with large slope, which provides effective parameters for the improvement and actual operation of the machine.

1. Introduction

Along with the gradual increase of China's support for the agricultural industry and the continuous development of the fruit industry, the total area of fruit planting in China has continuously increased. According to the data, the total area of fruit (including fruits and fruits) in China was 172.5 million hectares at the end of 2016, and the annual fruit output reached 283.19 million tons, with an annual growth rate of 3.4%[1], making it a leading fruit producing country. China has a large land area, but the terrain is more complex, mainly mountainous hills, accounting for about two-thirds of the total area. Most of the orchard planting in China is located in the hilly and mountainous areas, with rugged terrain, complex terrain and large slope. It mainly relies on artificial flocculation and picking. It is not only labor intensive, high cost, but also to some extent limit the progress of mechanization and automation of orchard planting. Therefore, the orchard operation machinery plays an important role in the process of picking, trimming and transporting mountain orchards. In order to reduce the labor intensity of mountain orchard operation and improve labor efficiency, this paper designs an orchard operation platform machinery, which can better apply mountain terrain and help staff to carry out the operation inside the orchard[4–7].

In this paper, the problem of difficult operation and poor driving stability in the hilly area of the orchard is studied. Firstly, the overall 3D model of the orchard work platform was created by Solidworks software and imported into Adams software for simulation analysis. The combination of Adams software and virtual simulation technology was used to change the slope of the mechanical driving in real time. When the orchard work platform runs on the varying terrain slope, the maximum...
slope of the terrain that the orchard work platform can travel can be verified by changing the driving force. This paper designs a virtual experiment to verify the critical running terrain of the machine, solves the tipping condition of the orchard working machine, verifies the feasibility of the operation of the orchard working platform, and provides reference data for the later optimization design of the machine.

2. model creation
For the climbing ability test of the orchard work platform, the Solidworks 3D software is used to build the model. The machine adopts the crawler chassis as the walking system, which enhances the climbing ability, carrying capacity and traction of the machine. It has good driving performance and high passing performance, and can better adapt to mountainous terrain with a certain slope. Hydraulic transmission control is used to control the expansion and contraction. The machine uses hydraulic transmission to control the lifting of the telescopic cylinder to achieve the leveling operation of the orchard work platform. And use the single-chip microcomputer as the main control center, through the relay's opening and closing control loop interruption and mechanical movement posture [8].

When building a simulation model in Adams, we first create a slope that can be freely angled. For smaller, trivial parts, you can use them all to round up the larger important parts using the Boolean method. We can completely eliminate the trivial small parts and use the Boolean method to merge larger important parts. The hinge point of the rotary auxiliary pair fixed telescopic cylinder is added, and the sliding pair is added to determine the expansion and contraction of the cylinder, and the joints are kept rigidly connected. When starting the simulation, set other irrelevant parameters to a fixed value to avoid affecting the simulation results. By applying different driving forces to the machine, changing the acceleration of the mechanical operation, controlling the two independent variables of the slope angle and acceleration, the climbing ability of the orchard work platform is analyzed. Its solid model structure is shown in Figure 1.

![Figure 1 Orchard Work Platform Solid Model](image)

3. Work needs analysis

3.1. Working objects
The orchard operation platform mainly deals with the hilly area, especially the slope topography with a certain slope. To ensure the safety of the workers, it is particularly important to determine the climbing ability and tipping threshold of the machine. The overall weight of the machine is about 1400kg (including the load), which is mainly composed of four parts. The first part is the driving part composed of diesel engine and hydraulic oil tank, the second part is the running mechanism composed of the crawler type chassis, and the third part is the rotating table and the supporting mechanism consisting of the horizontal slope leveling cylinder, the fourth part is the mechanism consisting of the hanging basket, the lifting cylinder and the vertical slope leveling cylinder. The loading platform load is 140kg, which is responsible for the work of the orchard laborers and the fruit picked. Among them, the total weight of the hydraulic drive and the crawler chassis is about 800kg, accounting for 57.1% of the total weight. The parameter design is shown in Table 1.
Table 1 Mechanical overall data

| mechanical component | Hydraulic system (G1) | Track chassis (G2) | Support member (G3) | Picking platform (G4) |
|----------------------|-----------------------|--------------------|--------------------|----------------------|
| Quality / kg         | 580                   | 420                | 260                | 140                  |
| Lateral distance / m | 1.5                   | 1.5                | 0.73               | 0.7                  |
| Longitudinal distance / m | 0.9          | 1.89               | 0.85               | 1.78                 |

Since the mechanical tilting is closely related to the overall center position of the machine, in order to ensure the accuracy of the climbing performance simulation experiment of the orchard working platform, the mass center position of the overall machine should be determined when adding the material in the Adams software to prevent the center of mass. The offset causes the accuracy of the data to decrease. During the upward movement of the machine from the bottom of the slope, the drive wheel is used as the object, a certain amount of torque is applied, and the angle of the slope is continuously changed to measure whether the machine can continue to operate at the maximum allowable slope.

3.2. Structure and stability analysis

The orchard work platform is mainly supported by plane support, as shown in Figure 2.

![Figure 2 Mechanical support platform](image)

The front of the mechanical platform is equipped with a hanging basket as a working platform, which is responsible for supporting the orchard staff to work on pollination and fruit picking. The crawler chassis adopts the rear wheel drive mode, and its traveling plane is ABCD plane. When the machine is tilted in the longitudinal direction, the tilting axis is AB line. During the mechanical climbing process, due to the excessive weight of the hydraulic oil and the diesel engine, when the machine is started, it is easy to cause the machine to tip over at the end of the track grounding, which threatens the safety of the platform staff.

When the machine is tipped over, the front end of the vehicle body will be slightly lifted, causing a large vibration of the vehicle body, causing discomfort to the laborers standing on the platform, which may easily cause collision and abrasion of the fruit attached to the side of the platform. When the slope is too large, the degree of tipping is further deepened, and the machine may roll over the AB line of the crawler chassis as a fulcrum. The safety of the crisis workers causes damage to personnel, machinery and goods. Therefore, it is particularly important to use the Adams software to simulate and analyze the climbing test of the orchard work platform[9~11].

4. ADAMS motion simulation

Import the model created in Solidworks into Adams. Before the simulation analysis, we edit the whole machine, change the color of the important parts, name material attributes, etc., to facilitate the addition of the later activities [12~14]. In order to better analyze the simulation results, focus on
variables such as position, velocity and acceleration of the marker points. Marker points are added to important parts, Marker points are used as mechanical movement or rotation marks, and the traces and information of Marker points are processed after simulation to replace the important parts to be studied. After creating the marker points, create a motion sub-constraint relationship in Adams. The result is shown in Figure 3.

4.1. slope change
The machine starts running on a slope with a slope with a variable ramp angle and an initial angle of 30°. The simulation time (EndTime) is set to 15s and the step count is 1000. The drive is added to the drive wheels of the two tracks. The force received by the machine as a whole is parallel to the plane of the slope, and the size is -50d*time. The simulation process is divided into two stages, the first stage is 0 to 7.5 seconds. At 0 seconds, the slope of the slope is 30°, then the inclination angle begins to decrease gradually. At 7.5 seconds, the slope is less than 0°. The second stage is 7.5 seconds to 15 seconds. The slope of the slope of this stage begins to increase gradually, and the slope becomes 35° at the end of 15 seconds. The drive function for the change in the slope angle is STEP (time, 0, 0d, 7.5, 30d) + STEP (time, 7.5, 0d, 15, -35d). The MOTION3 added on the slope is used as the observation target. After the simulation is finished, the driving force on the slope and the angular velocity of the slope in Adams can be observed through the post-processing stage, as shown in Fig. 4 and Fig. 5.
4.2. Mechanical changes

After the ramp program is designed, the machine can be considered as a whole. By marking the Marker points on the track chassis, the post-processing and analysis of the Marker points can be used to replace the changes in the overall machine during the simulation. After the simulation is over, analyze the trend of mechanical acceleration. As a result of mechanical analysis, the overall operation of the machine can be decomposed into speeds and accelerations along the X, Y and Z axes. In Figure 2, the machine travels along the slope, with the positive direction of the Y-axis and the positive direction of the X-axis to the right.

When the machine runs along the X-axis direction, it creates a working torque for the drive wheel. The speed at which the machine starts running is 1m/s, and the acceleration is 0.5m/s². In the 0s~7.5s phase, the total acceleration is reduced with the slope. To reduce the trend, the speed trend first increases and then decreases. In the 7.5s~15s phase, as the slope of the slope increases gradually, the mechanical forward trend is hindered. By increasing the driving force, the acceleration trend begins to rise rapidly and the mechanical speed gradually increases. When the machine is running along the Y-axis, its speed trend is related to the rise and fall of the slope, showing a sinusoidal trend. The mechanical speed and acceleration trend changes are shown in Figures 6 and 7.

5. Conclusion

1) The virtual prototype model of the orchard operation platform constructed in this paper can better reflect the true characteristics of the machine. In the Adams environment, the constraints are added to the drive wheel and the slope, and the trajectory function of controlling the normal operation of the machine is obtained. The simulation effect of the mechanism operation is consistent with the theoretical analysis of the actual mechanics, and the simulation structure data is true and reliable.

2) Taking the slope change as the analysis object, the slope of the slope is determined to be 35°. From the curve of the displacement, velocity and acceleration of the marked point, the machine does not have obvious overturning phenomenon under this state. The simulation results show that the orchard work platform can be applied to mountainous terrain with a slope of not more than 35°.

3) Acceleration and slope are taken as two variables of the virtual experiment. The mechanical tilting state is used as the response value. The result shows that the velocity changes are more severe,
that is, when the acceleration fluctuation is large, the machine generates a large tremor, which affects the mechanical operation. It is stable and easily leads to mechanical dumping accidents.

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