Design of ditching fertilization structure of rubber tree particles fertilizer based on visual surveillance elements

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Abstract. There are large fertilization/more times/environment complex during natural rubber tree in the process of the growth cycle and difficult to monitor, aim to the special rubber particles fertilizer easy to deliquescence and cause pipe blockage and then lead to fertilization breaks leakage problem, this paper designed a kind of convenient for visual surveillance of rubber particles ditching fertilizer structure. Optimal designed and analyzed reliability its structure characteristics/working principle/core components and monitoring method. The self-running power suspension test shows that when the moisture content of the fertilizer is \( \leq 0.16 \), the scraping structure has no obvious stick with fertilizer go down smoothly, and the strip breaking rate index is \( \leq 0.06 \), the structure basic function indexes meet the design requirements.

1. Introduction

Natural rubber is an important strategic material resource in China. It needs to be fertilized several times during the growth cycle to meet the energy supply of high-yield glue. At present, fertilization is basically carried out under the contracting system. Due to the continuous low price of natural rubber in the country and the inadequacy of management methods, fertilization is difficult to ensure sufficient and correct timely application. For this purpose, a fertilization capable of real-time monitoring of operations can be developed. The machine is of obvious significance.

In China, research based on visual monitoring has not been reported yet, but research has begun on precision and precise fertilization control. Wang Xiu and others mainly developed precision variable fertilizer applicators. Although the developed tools have small errors in the process of variables, they are not suitable for large-area operations. Qin Chaomin and others studied the centrifugal spreader\(^1\). By analyzing the influence of the arrangement of the pusher plate on the spreading disc on the movement of the fertilizer pellet on the spreading disc, the pusher board was obtained on the spreading disc. The layout of the fertilizer particles is calculated\(^2\).

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 centrifugal spreader developed in Australia is relatively simple in structure and high in production
efficiency, but it is not suitable for domestic use based on cost and environmental compatibility[3-4]. The ultrasonic sensor system developed by Saeyes et al. is used in a ditching and fertilizing machine to automatically adjust the ditch depth[5-7]. The CASE860 chain trencher and the T-1255 chain trencher developed by the American company have been equipped with more advanced devices, but only can achieve a single function of trenching[8-9].

The development of visual monitoring-based fertilization technology will have a positive guiding role in the monitoring of fertilization indicators, the development of intelligent agricultural machinery and the integration of human-computer interaction technology[10-12].

2. Ditching fertilization structure design

The design of the trenching fertilization structure is based on the full consideration of fertilizer fluidity, passability and impulsiveness, and mainly consists of a combined structure of fertilization tank fertilizer, fertilizer control fertilizer, scraper board and fertilizer. The design and visual monitoring methods are basically selected in the fattening process to ensure the simultaneous monitoring, control and quantity of fertilizer.

2.1. Fertilization box design

The fertilization tank is the basic part of the fertilizer and plays a role in the fertilization reserve. The fertilization box is designed to have the shape of the chute of the grid. Firstly, the relative sliding of the fertilizer can be realized by the weight of the fertilizer; the second is to mix the fertilizer while the fertilizer is mixed; the third is to avoid the fertilizer after the deliquescence After the viscosity changes, it sticks to the inner wall of the fertilizer box, which causes the phenomenon of poor fatness.

Its structure is mainly composed of fertilization box, grid plate, bottom plate and lower fat hole, as shown in Figure 1.

2.2. Design of fertilizer control mechanism

The fertilizer in the fertilization tank is discharged to the driving turntable through the lower fat hole. When the speed reducer drives the turntable, the fertilizer of the box above the lower fat hole forms a relative movement with the fertilizer on the following driving turntable, and the fertilizer continues under the relative motion. Discharge, while driving the turntable and the scraper plate fixed on the support frame also has a relative mechanical movement, accompanied by the rotation of the drive turntable, the hindrance of the scraper plate will ridge the fertilizer in the disk, when the fertilizer ridge height is greater than When the height of the turntable edge is high, the fertilizer is discharged under the guiding action into the lower fertilizer pipe.
2.3. Lower fat structure design
The lower fertilizer structure is funnel-shaped and is installed directly under the scraping board to play the role of the fertilizer scraped off by the scraping board in the lower fat barrel, and is discharged into the opened ditch through the discharging tube. The lower fertilizer structure adopts 304 stainless steel material, and the design of the baffle plate is 36mm high, which can effectively block the fertilizer from leaking. The angle of the cone from the top to the bottom is $45^\circ$, which helps the fertilizer to fall by gravity, has strong bearing capacity, and can be effective. Solve the problem of fertilizer blockage and slow falling speed.

2.4. Plow structure design
The trenching plow is the core component of the trenching system. The upper two holes of the spindle can be adjusted by the pin and the frame beam hole to adjust the different positions, thereby adjusting the depth of the deep trench plow.

3. Design of visual monitoring system
The core components of the visual monitoring system mainly include: host control box, rounded camera, digital display, GPS antenna, sensor components and supporting components. Among them, the sensors mainly include: an image sensor is used to acquire an operation effect of an agricultural
machine, an image of a job type, and an image processing algorithm is used to extract relevant information. The plow identification sensor is used to obtain the types of deep and shallow trenches. The specific installation location of the relevant core components is shown in Figure 5.

![Figure 5. Visual monitoring installation interface](image1)

The rubber trenching fertilizer applicator after installing the visual monitoring system can monitor the work track, work area, work tool type and depth index in real time, and can also collect data and query historical data.

![Figure 6. Trajectory monitoring effect chart](image2)

4. Test verification

4.1. Test conditions and phenomena
The test materials are: 3XSP-1 rubber fertilizer applicator, supporting rubber special granular fertilizer and stopwatch, FA2004 electronic balance, meter ruler, storage bag, broom, cymbal, marker and other tools. In the agricultural machinery research institute of the Agricultural Research Institute of the China Academy of Tropical Agricultural Sciences, Zhanjiang City, Guangdong Province, the weather is fine and the temperature is between 29.5 and 35 degrees. See Figure 7.

![Figure 7. Test view](image3)

The rubber trenching fertilizer applicator after installing the visual monitoring system can monitor the work track, work area, work tool type and depth index in real time, and can also collect data and query historical data.
4.2. Test plan

4.2.1 Depth depth and its stability

A point is measured every 2 m, and no less than 10 points are measured per stroke, and the depth of each point is measured. And calculate the ditch depth average and its stability coefficient according to the following formula.

**Average ditch depth of A stroke**

\[
a_j = \frac{\sum A_{j1}}{N_j} \]

Where: \( a_j \) - the average of the ditch depth of the jth itinerary;
\( A_{j1} \) — the depth value of the ith measurement point in the jth itinerary;
\( N_j \) — Measures the number of points in the jth itinerary.

**Ditch depth average of B conditions**

\[
a = \frac{\sum a_j}{N} \]

Where: \( a \) — the average of the ditch depth of the working condition;
\( N \) — The number of trips in the same operating condition.

**Ditch depth stability factor for C stroke**

\[
S_j = \sqrt{\frac{\sum (a_j - \bar{a})^2}{N_j - 1}} \]

\[
V_j = \frac{S_j}{a_j} \times 100\% \]

\[
U_j = 1 - V_j \]

Where: \( S_j \) — the standard deviation of the ditch depth of the jth stroke, cm;
\( V_j \) — coefficient of variation of the d-th groove depth of the j-th stroke, %;
\( U_j \) — d-stitch depth stability factor, %.

**Ditch depth stability factor for D condition**

\[
S = \sqrt{\frac{\sum S_j^2}{N}} \]

\[
V = \frac{S}{a} \times 100\% \]

\[
U = 1 - V \]

Where: \( S \) — the standard deviation of the trenching depth of the working condition, cm;
4.2.2 Fertilization uniformity
In a flat concrete floor or other clean place, the machine will travel 20m at normal working speed, take 3 points, the length of each point is not less than 2m, divide the small section every 20cm, and measure the fertilizer quality in each small section, and according to 5.3.4.1 The relevant calculation formula calculates the uniform coefficient of variation of fertilization.

4.2.3 Fertilization breaking rate
The non-fertilizer section with a length of 10 cm or more is broken, and the number of broken bars and the length of the broken strips are measured within 3 m, and the total length of the broken strips is calculated as a percentage of the total length of the drained fertilizer of 3 m. It was measured three times and averaged.

5. Discussion
1) The designed ditch and fertilization structure adopts grid-type box body, combined with scraper-type fertilizer and conical fertilizer structure, which can effectively avoid sticking, leaking and blocking. After integrating the visual monitoring system, the operation track is realized. Monitoring of work area, work tool type, depth indicator, etc.
2) The self-propelled power suspension test shows that when the fertilizer deliquency is \( \leq 0.16 \), the fertilizer structure has no obvious blocking, the fertilizer is smooth, and the broken rate index is \( \leq 0.06 \), and the basic functional index of the mechanism meets the design requirements.

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