Design and test of CF-1A self-propelled residual film recover machine

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Abstract. At present, although China has developed a biodegradable film, its impact is not ideal that the cost of degradation of the film is higher, and more difficult to promote widely. In order to solve the current problem of picking up the remains of the domestic films, the CF-1A self-propelled residual film recoverable machine is designed. The core components of equipment are the Swing-type residual film picking part and the membrane tooth separation mechanism. The test results have showed that residual film recoverable machine pick-up rate reaches at 82.5% to satisfy the farmers pick-up of the agricultural requirements on the residual film and provides a new idea for the design of the residual film picker.

1. Introduction

These Plastic film mulching cultivation has been widely used in china agricultural production due to the benefits such as increasing soil temperature, enhancing the efficiency of fertilizers and water levels, improving total soil porosity, reducing soil erosion, and increasing crop yield and quality. the plastic film mulching area in China is more than 20million hm² by the end of 2017, and this technology provides significant support for the crop yield improvement and food security[1-7].

Nevertheless, the films used in China were mostly the conventional plastic films made from polyethylene, which cannot be naturally biodegraded in the field [8-10]. At present, Only a small fraction of the plastic films is currently recycled due to the expense and time required for recycling, and a large portion of plastic films is left on the field or burnt uncontrollably by the farmers [11-14]. Therefore, there is an urgent need for a kind of residual film recover machine which is suitable for Chinese plastic film mulching cultivation with high pickup efficiency and reduce labor cost.

Since 1970s, relevant studies of residual film recover machine had been developed overseas. However, the films used in China were mostly the thin plastic films made from polyethylene, a film thickness of 0.004mm-0.006mm. so, Foreign residual film recover machine does not apply to China’s reality.

In recent years, China has also developed relevant studies on residual film recover machine. panpan Yan et al. Research on the Spring-tooth-chain-rake Incomplete plastic film recycling machine. It highlights the aircraft’s overall structure, working principle, key components such as pick-up chain harrow, spring-tooth, taking off the membrane mechanism for design analysis. field test showed that
the plastic film recycling machine production rate is 0.85hm²/h, recovery of plastic film is 81% [15]. However, this machine also has the shortcomings of bad lubrication, the high failure rate.

Zhaoyan You et al. Design and experiment of 1MCDS-100A typed shovel-sieve residual film recovery machine. The experimental results showed the machine forward speed was 0.73 m/s, amplitude of saw-tooth sieve was 99 mm, vibration frequency of saw-tooth sieve was 280 r/min, saw-tooth distance was 12 mm, when the recovery rate of residual film was 91.26%, rate of winded film was 4.27% and film soil ratio was 2.16[16]. But it has a up and down parallel arranged double-sieve type self-balancing machine, complex, expensive, difficult to maintain.

Wei Zhang et al. design a kind of 2TM-120 type residual film recycling machine. The results indicated that the residual film collecting rate could reach 85% or more and the twine rate was less than 2% [17], it have been designed to address “how to pick up”, however, the problem of “how to unload” is overlooked. Therefore, this article designs CF-1A self-propelled residual film recover machine which can complete the plastic film recycling and meet the technical requirements. The research results may help solve the problem of plastic film pollution.

2. Overall structure and working principle

2.1. Overall structure

The CF-1A self-propelled residual film recoverable machine mainly is composed of a frame and a plastic film residue collector includes a collection box, a conveying device, an air separation device, a steering system, and a hydraulic system etc. The harvester adopts a self-propelled walking device with the rear wheels playing a role in steering. The overall structure is illustrated in Figures (Fig. 1) and the main technical parameters listed in Tables (Table 1).

| Parameters                  | Values       |
|-----------------------------|--------------|
| Structure form              | Self-propelled|
| Frame height adjustment mode| Hydraulic    |
| Overall dimension (L×W×H)/mm| 4265×1760×2150|
| Engine rated power/kW       | 65           |
| Engine rated speed/r·min⁻¹  | 2700         |
| Work speed/km·h⁻¹            | 20           |
| Overall mass/kg              | 2735         |
| Row spacing/mm              | 1665         |
| Wheel-tread/mm               | 315          |

2.2. Working principle

The operating principle of the CF-1A self-propelled residual film recoverable machine is as follows. For one thing, the residual film is chopped by the Low-speed stubble extinguisher and scooped up from the ground by the shovels and scraped upwards onto the conveying belt by the rotating scraper component. With the scraper component and the belt rotating in opposite directions of an equal linear velocity, the residual film is clamped and conveyed by the belt. For another thing, the residual film is blown off and down into the collection box by the action of the film removing. Meanwhile, sundries will be removed by the air separation device in the residual film which falls into the collection box.

With advancing of the residual film recoverable machine, the overall ground height is accommodated by adjusting two hydraulic cylinders connecting the frame to adapt the residual film recovery in different farming area during operation. Steering system is bedded in rear side of frame, which is the vehicle assistant steering mechanism of the self-propelled residual film recoverable machine. To realize steering with convenient operation, especially, steering wheel is suitable for the residual film recovery between narrow and small sections among lines.
3. Design and description of critical components

The swing-type residual film picking part and the membrane tooth separation mechanism are the core components of the CF-1A self-propelled residual film recoverable machine. On the one hand, swing-type residual film pick-up part decides the pick-up machine, performance and efficiency, on the other hand, membrane tooth separation mechanism decides the reliability and continuity of the pick-up machine work.

3.1. Swing-type residual film picking mechanism

The swing-type residual film selectors choose pick-up mechanism consisting of picking mechanism hanger, moving sprocket, drive sprocket, drive shaft, chain and L-shaped pick-up teeth, which has shown in Figures (Fig. 2). First of all, the pick-up mechanism hangs on the left and right side of each installation of the driven belt wheels and drive sprocket. Furthermore, the chain is perched lower side installation L-shaped pick-up teeth.

![Figure 2. Structure diagram of swing-type residual film picking mechanism](image)

1. picking mechanism hanger  2. moving sprocket  3. drive sprocket  4. drive shaft  5. chain  6. L-shaped pick-up teeth

The drive shaft actuates sprocket to promote the chain for swing movement and mounts on the lower side of the Chain L-shaped pick-up teeth for swing relative movement to achieve L-shaped pick-up teeth in one side after picking up the debris film bypass to the other sides.

3.2. Membrane tooth separation mechanism

The membrane tooth separation mechanism is illustrated by several facilities including the S-type chassis, residual film separation inlet, installation of lifting ears, separation roller drive shaft, drainage port, separation roller, flexible separation teeth and residual film drain outlet, which is shown in Figures (Fig. 3).
Firstly, the left and right sides of the S-type housing are equipped with mounting lifting ears. Secondly, the front side of the S-type case is set with the residual film separation entrance. Thirdly, the rear side of the S-type case is placed with the residual film row outlet. Fourthly, the residual film separation entrance is put with a drainage outlet and the residual film separation entrance installation separation roller. Lastly, the outer surface of the separation roller is fitted with flexible separation teeth and the separation roller side is equal to a separation roller drive shaft.

4. Test and results

In order to test the operation performance of the CF-1A self-propelled residual film recoverable machine, the whole set of experiments were carried out in the Taohai Farm, Ningcheng County, Chifeng City, Inner Mongolia Autonomous Region on October 30, 2018. The test object was 40 acres of corn field to grow the residual film. The appearance of the residual film pick-up device is shown in Figures (Fig. 4).

Figure 4. Appearance chart of the residual film pick-up device
The experimental results have shown that the pick-up efficiency of the CF-1A self-propelled residual film recoverable machine can reach by 82.5%. When selecting the appropriate speed of the whole machine, the swing speed of the residual film pick-up device and the speed of the membrane tooth separation mechanism can make it rapidly.

5. Conclusions
At present, although China has developed a biodegradable film, its effect is not ideal that the cost of recession of the film is higher and harder to boost far-ranging. Therefore, the recovery of cheaper film is still the main task at this stage. In the end, the CF-1A self-propelled residual film recoverable machine is projected. The test results have showed that residual film recoverable machine pick-up rate reaches at 82.5% to meet the farmers on the residual film pick-up of the agricultural requirements and provides a new idea for the pickers with the design of the residual film.

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