Design and Test of Wind Plate-type Residual Membrane Hybrid Separator

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Abstract. In order to realize the effective separation of the residual membrane mixture, this paper designs the wind plate-type membrane hybrid separation device, which is composed of square air box, residual film discharge, conveyor belt, wind plate, soil and orange stalks shredded final row outlet, drive shaft, residual membrane mixture inlet, drive belt wheel and driven belt wheel, through analysis to determine the drain-outlet shape, number of wind plates and wind plate materials. Experiments showed that the membrane hybrid separation rate of membrane hybrid separation device is 91.5%, which meets the requirements of agronomy and realizes the effective separation of residual membrane mixture.

1. Introduction
The farmland film cover planting technology has been introduced into China since the 1970s. The technique of mulch planting is not only beneficial to the growth of crops, but also can effectively curb the growth of weeds, prevent the loss of soil, water and fertilizer, and also have obvious effects on maintaining the growth temperature of crops and resistance to frost damage. Based on the many advantages of farmland film, the use of mulch ingestion for planting has greatly contributed to the early ripening of crops and the increase of yield. As the application of film cover planting technology in farmland not only greatly promotes the increase of agricultural production, but also makes farmers income further increase, the methods of film planting in field production has been widely used and popularized in the domestic field crop cultivation[1-4].

However, in the process of planting with farmland film cover, there is a huge ecological environment crisis of farmland. Lack of effective film recycling tools for farmers, the resulting in the recovery of the field film before the cultivation operation. Therefore, a large number of field debris in the agricultural deep before the deep turn can not be recycled in time, and with the field debris accumulation, and ultimately to the farmland ecological environment caused serious "white pollution". The longer the continuous coating time, the greater the residual residue mount, the greater the impact on crop yield. If the livestock eat the residue by mistake, it will cause disease, and serious lying will lead to death. When domestic animals eat leaves and straw containing residual membranes, they can cause intestinal diseases which can lead to death in serious cases. The problem of residual
membrane has now endangered the sustainable development of agriculture and increased farmers' income. It can be seen that the treatment of residual film pollution is not only to protect the agricultural ecological environment and the sustainable development of agriculture, but also the key to the healthy and sustainable development of the residual film covering this important agronomic technology [5-6].

For the treatment of residual film pollution is a systematic project. Only through comprehensive management measures can this problem be fundamentally solved. Residual film pollution is mainly physical pollution, which can be reduced or avoided by improving the quality of the residual film and strengthening the means of recovery and other methods. For example, biodegradation and photodegradation residual film can be used to solve the pollution source problem and the technical difficulties of developing residual film recycling tools. However, at present, farmers' income is relatively low. If the use of degraded residual film is forced and the thickness of the residual film is increased, the cost of agricultural production will be increased, which is unacceptable to farmers. Therefore, the treatment of residual film pollution is currently mainly through recycling to limit its impact on agriculture. At present, the recovery methods of field agricultural land film are mainly mechanized recovery of residual film and artificial recovery of residual film. For the manual recovery of residual film, its disadvantages are that the work efficiency is relatively low, and the labor cost is relatively large. Therefore, the method of artificial recovery of residual film is not very significant in solving the pollution of debris in farmland. In order to improve the efficiency of agricultural residual film field recovery and reduce the operating cost, mechanized recovery of residual film is undoubtedly the best method at present [7-10].

2. Overall structure and working principle

2.1 Overall structure

At present, China's agricultural machinery and technology personnel have developed various types of residual film recovery machinery and equipment, from the existing residual film recovery machine operation process, which can be divided into the following 4 processes: film starting, film picking, defilming and discharge of membrane operation process. But the film after being discharged not only contains the residual film but also soil and orange terrier. This kind of residual film can not be recycled by enterprises, and it is also difficult for the government to develop the recovery compensation standards. Many farmers after receiving directly into the field or ditch, and caused secondary pollution. In view of this situation, a wind plate membrane hybrid separation device is designed, as shown in Figure 1.

![Figure 1. Overall structure diagram.](image)

(a) Oblique view (b) Section view
1. square air box, 2. residual film discharge, 3. conveyor belt, 4. wind plate, 5. soil and orange terrier shredding end row outlet, 6. drive shaft, 7. residual membrane mixture inlet, 8. drive belt wheel, 9. driven belt wheel

Figure 1. Overall structure diagram.

Wind plate-type membrane hybrid separation device sprig includes square air box, residual film discharge, conveyor belt, wind plate, soil and orange terrier shredding end row outlet, drive shaft, residual membrane mixture inlet, drive belt wheel and driven belt wheel. The lower end of the front and orange terriers of the square air box is set with soil and orange stalks, the upper rear of the square
air box is set with the residual film mixture inlet, the upper front of the square air box is equipped with a residual film row outlet, the front side of the air box is fitted with a drive belt wheel, the rear side of the wind box is fitted with a driven strap wheel, and the drive wheel side connecting shaft drive end is set. The other end of the drive shaft extends the side of the square air box, connects the drive wheel and the driven wheel on the inside of the conveyor belt, and installs the air plate on the outside of the conveyor belt. Part design

2.2 Working principle
In use, the drive shaft is connected with an external motor. Under the action of the external motor, the drive belt wheel drives the spin wheel to rotate through the conveyor belt. The air plate mounted on the outside of the conveyor belt rotates with the conveyor belt around the drive wheel and the driven belt wheel. The residual film, soil and orange terrier shredding picked up by the residual film picker enter the wind plate-type membrane hybrid separation device through the inlet of the residual membrane mixture. The residual membrane mixture is suspended forward by the wind plate movement. Because of the high density of the soil, the first falls into the conveyor belt in the forward motion, with the conveyor belt bypassing the drive shaft, it is removed from the dirt and orange terrier final row outlet steamed by gravity and wind force. The density of the orange stalk is close to the residual film, but the residual film recycler received the orange stalks of the end of the volume is larger than the residual film, its mass is also large, under the action of the wind plate, from the inlet of the membrane miscellaneous separation device to the outlet movement, gradually separated from the residual film and gradually fell into the root of the wind plate, with the conveyor belt bypass the drive shaft, discharge from the dirt and the end-drain exit of the orange terrier under the action of the wind plate. Residual film because of its light mass, small density, is always suspended at the edge of the wind plate, after reaching the residual film outlet, in the wind plate-driven wind effect from the residual film outlet blown out. The wind plate-type membrane hybrid separation device uses the difference in volume and density of the residual film, soil and orange terrier, and realizes the separation of the residual film from impurities by the action of the wind plate and gravity.

3. Core component design

3.1 Selection of outlet shape
The front of the square wind box at the lower end is set with soil and orange terrier shredded end row exit, the square wind box on the upper side of the front is set with the residual film row outlet, as shown in Figure 2.

![Figure 2](image)

1. square air box, 2. soil and orange terrier shredding end row outlet, 3. drive shaft, 4. residual film discharge

In the conveyor air duct of the various local air flow outlets, when the wind plate movement produces the same total air flow through the outlets, the size of the air flow, direction to change. As a result, local resistance occurs as it flows through the outlets of the airflow. Local resistance can be calculated by the following formula:
\[ F = \frac{1}{2} k \rho v^2 \]

Where:  
- \( F \): Airflow outlet resistance, Pa;  
- \( k \): Resistance coefficient;  
- \( \rho \): Airflow density, Kg/m³;  
- \( v \): Airflow velocity, m/s;

Through the formula can be seen, only the resistance coefficients are different, all the others are the same. The resistance coefficient can be obtained by looking up the table, the result is that the circular drag coefficient is less than the square drag coefficient, then the resistance of the circular airflow outlet is less than the resistance at the exit of the square airflow. In order to meet the needs of the wind plate-type membrane hybrid separation device, in the case of the total flow of airflow unchanged, the airflow force at the outlet should be as small as possible, to avoid the orange terrier crushing end with the residual film to take off. Based on the above theoretical calculation and analysis, the paper intends to use the rectangular outlet as the shape of the residual membrane or the last row of orange terrier.

### 3.2 Wind plate quantity analysis

The arrangement of the wind plate and configuration spacing as shown in Figure 3. When the wind plate-type membrane hybrid separation device is working, if the number of wind plate arrangement is too small and the distance between the two wind plates between is greater, the work efficiency will be reduced. At the same time, because the speed of the wind plate transmission can not be too high, when one of the wind plates scrapes the residual membrane mixture, then another wind plate due to excessive spacing can not be in a timely manner to scrape the newly entered residual membrane mixture, then it is easy to cause the residual film separation efficiency to decrease; which will affect the reliability of the transmission of the entire wind plate-type membrane hybrid unit. As a result, the number of wind plates installed in a week is 15.

![Figure 3. Wind plate layout schematic](image)

### 3.3 Wind plate material selection

When the wind plate to the residual film mixture to the various outlets, because the residual film has easy adsorption characteristics, in the air flow speed is not large, the residual film may not be blown off, and then will be winded on the wind, and ultimately affect the recovery of the residual film. Therefore, the difference of the adsorption characteristics of the residual film to the air plate on different materials were analyzed, and the suitable material for making the wind plate were obtained.

In this paper in the selection of wind plate materials mainly from iron, rubber canvas and hard plastic three materials to choose. Taking into account the easy adsorption characteristics of the residual film, because the tension on the surface of the residual film, electrostatic force and friction on the iron material wind plate are more likely to cause the residual film adsorption. Therefore, the wind plate made of iron material will not be suitable for use in the air defilm. For the rubber canvas materials and hard plastic materials made of wind plate, the residual film of these two materials adsorption compared with iron materials, the effect is poor, it is more suitable for the choice of wind plate material. At the same time, considering that the wind plate is installed on the conveyor belt and has a certain movement speed and the force is greater, so the wind plate made of rubber material is more in line with the actual requirements than the wind plate made of hard plastic. Synthesis of the
above analysis, the rubber canvas material is finally choosed as the production material of the wind plate. Rubber canvas wind plate has good wear resistance, toughness, not easy to adhere to the residual film and other advantages.

4. Test and results
The experimental equipment shows as shown in Figure 4.

![Figure 4. Structure of experimental equipment](image)

In this test, the membrane hybrid separation rate is used as the test index, the membrane hybrid separation rate can be calculated by pressing:

$$\eta = \frac{m_1}{m_1 + m_2}$$

Where: $\eta$: The efficiency of the wind plate-type residual film miscellaneous impurity separation device;

$m_1$: Residual film mass, g;

$m_2$: Impurity quality, g.

Experiments show that the membrane hybrid separation rate of the wind plate-type membrane hybrid separation device is 91.5%.

5. Conclusion
In order to realize the effective separation of the residual membrane mixture, this paper designs the wind plate-type membrane hybrid separation device, which is composed of square air box, residual film discharge, conveyor belt, wind plate, soil and orange stalks shredded final row outlet, drive shaft, residual membrane mixture inlet, drive belt wheel and driven belt wheel, through analysis to determine the drain-outlet shape, number of wind plates and wind plate materials. Experiments showed that the membrane hybrid separation rate of membrane hybrid separation device is 91.5%, which meets the requirements of agronomy and realizes the effective separation of residual membrane mixture, and its research results are not only of great significance for the recycling and reuse of mechanized residual film, but also for engaging in complex mixed materials (e.g. agricultural residual film, Household waste) Separation and selection methods and related theoretical research have important reference value.

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