Design and Research of a New Type of Semi-Automatic Winding Seedling Packaging Machine

Keyue Jiang*, Yukun Qiu and Yizhen Qian
School of Mechanical and Electrical Engineering, Wuhan University of Technology, Wuhan 430070, China

*jky_1827@163.com

Abstract. The current seedling packaging industry has the problems of cumbersome packaging process and low packaging efficiency. This phenomenon does not correspond to the high throughput and efficient packaging efficiency of seedling network marketing under the background of the existing Internet big data era, and the slow efficiency is seriously hindered. The rapid development of the seedling industry. In response to this problem, this paper made in-depth research and found that the seedling packaging occasions are mostly outdoor, there are problems such as power supply inconvenience. This paper designed a semi-automatic seedling packaging machine driven by artificial power, which is powered by human footsteps. The four-bar mechanism transmits the foot power, the handwheel on the machine rotates to realize the clamping and fixing of the seedlings, and finally the gear train of the machine cooperates with the timing belt to provide the bidirectional winding power, and the upper and lower gears in the device drive the incomplete gear mechanism. Provides non-equal speed movement to achieve the winding and cutting of seedling wrap film. The Samsung wheel reversing mechanism can convert the winding method to realize the fast and complete winding of some seedlings (10cm-30cm), effectively improve the packaging efficiency, and enable the seedling network dealers to better adapt to the contemporary network business model. And provide technical reference for the research and design of similar products.

1. Introduction
Due to the continuous development of industry, the rapid advancement of science and technology, the large amount of "four wastes" caused by modern industrialization and the severe destruction of the natural environment caused by the rapid urbanization process, these developments have caused environmental and ecological imbalances, and caused air and soil pollution. Environmental problems such as the disappearance of forests and soil erosion, which seriously threaten the living environment of human beings. According to the principles of ecology and through landscaping measures, these measures can alleviate the existing urban environmental problems and restore the urban ecological circle to a certain extent, and enable the urban environment to meet people's needs in work, life and spirit [1].

In the context of deteriorating environmental conditions in modern cities, urban landscaping has become one of the important projects of urban modernization. Urban gardens not only beautify the environment, create comfortable places for citizens to visit, but also improve the status of the urban environment and create people and nature [2]. Harmonious ecological environment [3]. Only by
strengthening urban landscaping construction can we beautify the urban landscape, improve the investment environment, and fully realize the biodiversity, and the sustainable development of the eco-
city can be guaranteed [4]. Therefore, the level of landscaping has become a quality indicator to measure the level of urban modernization. The level of urban landscaping construction is the representative of the city image and a symbol of urban civilization [5].

The development prospects of the seedling industry are huge and can be called the sunrise industry. During the transportation of seedlings, if the seedlings are exposed to the sun and are hit by the wind for a long time, the seedlings will lose too much water, the quality will drop, and even die. Therefore, in the transportation to minimize the loss of water, this method can greatly improve the survival rate of seedlings, which puts high demands on the packaging and transportation of seedlings [6]. The current method of packing seedlings is more complicated, the process is cumbersome, and a lot of manpower and material resources are consumed in the process of packaging. The current method hinders the rapid development of the seedling industry to some extent [7].

In the process of landscaping, the seedlings often seen include needles and most of the evergreen broad-leaved tree species [8]. These seedlings have a large number of branches and leaves, and the transpiration of plants loses water, and in the process of emergence, workers usually, more roots are damaged [9]. After the seedlings and in the early stage of planting, the seedlings are easy to lose the water balance in the body, resulting in the death of the plants. Therefore, in the process of seedling emergence of such trees, it is required to bring soil balls to reduce root water loss and increase survival rate. Based on this, we designed an artificial power semi-automatic seedling packaging machine for this type of seedling [10].

2. The Project design

2.1. The overall design

The artificial power semi-automatic seedling packaging machine designed in this design mainly uses footsteps to provide power, transmits the foot power through the four-bar mechanism, and provides two-way winding power by the gear train with the timing belt. The hand wheel rotates to fix the seedlings, and the push rod changes. The meshing direction of the planet wheel and the gear piece is reversely packaged [11].

The artificial power semi-automatic seedling packaging machine designed in this time is divided into clamping module, power module and non-equal winding packaging module. The clamping module of the machine realizes the bidirectional positioning of the seedling branches by the mutual cooperation between the hand wheel, the worm gear, the gear rack and the trapezoidal tooth timing belt; the power module is powered by the human pedaling pedal, and utilizes The four-bar mechanism transmits power, combines the bevel gear to provide rotational power for the gear shaft, and provides the constant-speed rotational power to the symmetrical part of the gear shaft through the trapezoidal tooth timing belt, providing a two-way power source for the rotation of the upper gear train to ensure the gear train. Smooth rotation; the non-equal winding package module uses five-mode 24-tooth and 5-mode 20-tooth gears to drive the incomplete gear mechanism, and the machine can reach the upper and lower incomplete outer gear ring with a gear ratio difference of 1 Movement, so that there is a speed difference and a distance difference between the winding film column and the film column. The machine cooperates with the Samsung wheel reversing mechanism to engage the external incomplete gear to realize the bidirectional winding packaging of the seedling root system; the film winding of the machine after the packaging is completed The column and the film column reach a uniform position to cut the film, and the unpackaged film is continuously pasted onto the solid film column by the film column for subsequent packaging.
2.2. The Mechanism selection

2.2.1. Power source module design. The power module of the machine is used to provide power to the entire device to wrap the package. Referring to the pedal energizing principle of the old sewing machine, the pedal is repeatedly powered by the manpower to provide power. The principle of the four-bar mechanism is adopted. The pedal 1 drives the connecting rod 2 to rotate the eccentric 3, and the eccentric 3 supplies power to the upper device. The lower part of the pedal 1 has a return spring to facilitate the continuous stepping of the human foot to provide continuous power.

![Figure 1. Four-bar mechanism](image)

The pulley of the machine rotates and transmits to the bevel gear, and the rotation of the vertical direction is converted into the rotation in the horizontal direction by the bevel gear transmission, and is transmitted to the gear shaft to drive the upper 5 mold 24 teeth and the 5 mold 20 tooth gear to rotate; The machine synchronously transmits the movement of the gear shaft to the symmetrical gear shaft through the trapezoidal tooth timing belt, providing a bidirectional power source for the rotation of the upper gear train, ensuring the stability of the gear transmission and the stability of the gear rotation.

2.2.2. The design of non-equal winding packaging module
1) Design of incomplete gear mechanism
The incomplete gear mechanism of the machine includes the following aspects as shown in FIG. 2:
upper transmission gear 1, 2, lower transmission gear 3, 4, upper incomplete external gear 5, lower incomplete external gear 6, solid film column 7, the membrane column 8 and the membrane column 9 are wound.

![Figure 2. Incomplete gear mechanism diagram](image)

The incomplete gear mechanism of the machine can realize two co-rotating movements of the same gear corresponding to the corresponding transmission mechanism, and mesh with the hollow incomplete gear to drive the incomplete gear rotation, thereby ensuring that each seedling is horizontally One-way linear motion. The symmetrical gear shaft rotated by the belt drive rotates the upper and lower gears of
different numbers of teeth at the same speed to rotate the upper and lower incomplete external gears of
the same number of teeth, so that the transmission ratio difference between the upper and lower
incomplete external gears is 1 Speed exercise. The cling film is fixed on the film column, and the
segment is fixed on the solid film column, wherein the solid film column is fixed, and the film column
is connected with the upper incomplete external gear, and the film column is connected with the lower
incomplete external gear. The solid film column and the film column complete the pre-tightening and
winding function of the wrap film, and the gear ratio difference between the film column and the upper
and lower gears of the film column is 1 (the bottom is larger than the upper portion), and the speed
difference and the distance difference are generated. When the initial speed of the input shaft is constant,
after several cycles, the inner slit film column rotates one more turn than the upper film supply column,
and finally the film is cut.

2) Design of the Samsung wheel reversing mechanism

![Figure 3. Samsung wheel reversing mechanism](image)

Gear 1, gear 2, gear 3, upside down internal gear 4.

![Figure 4. Samsung wheel reversing mechanism](image)

Downward incomplete internal gear 5, the incomplete external gear of the machine drives the overall
movement of the Samsung wheel reversing train. When the gear 1 meshes with the upside down internal
gear, the gear 2 is an idler gear, and the gear 3 rotates clockwise. At this time, the wrapping film is fixed
on the pallet. The rotation of the lead screw runs upwards, and the root of the seedling is wrapped from
bottom to top; when the gear 2 meshes with the upwardly incomplete internal gear, the gear 1 is an idler,
and the gear 3 rotates counterclockwise, at which time the plastic wrap is fixed on the tray. With the
rotation of the screw shaft running downward, the roots of the seedlings are wrapped and wrapped from
top to bottom to realize the bidirectional wrapping of the roots of the seedlings.
3. Introduction to the workflow

3.1. The process of manually placing seedlings

The machine of this design requires the seedlings of the human hand-wrap package to be placed in the packaging area. By using a manual rocking the handwheel, the machine uses a worm gear and a rack and pinion mechanism to change the rotation of the handwheel in the vertical direction into a linear motion in the horizontal direction. The transmission of the trapezoidal toothed timing belt causes the clamping handles at both ends to simultaneously move to achieve centering and clamping of the seedlings.

The vertical rotation of the hand wheel is changed into the horizontal rotation of the worm wheel by the worm gear mechanism, and the rotation of the vertical shaft is transmitted to transmit the power to the rack and pinion mechanism, and the rotary motion of the gear is converted into the linear motion of the rack by the rack and pinion mechanism. A section of the clamping handle is connected to the rack along the rack to the center; when the gear rotates, the motion is transmitted to the symmetrical rack and pinion mechanism through the trapezoidal tooth timing belt, and at this time, the clamping shanks at both ends move toward the center at the same time. It ensures the clamping function of the device and the center position of the seedling packaging.

3.2. The process of wrapping the seedlings

The person uses the foot to step on the pedal to drive the double gear shaft to rotate. Each gear shaft has two gears with different modulus to drive the two incomplete gears with a gear ratio difference of 1; the winding column and the solid film column there is a cling film between them, and the pre-tightening force between the two columns allows the film to smoothly wrap the seedlings in the initial situation.

The triangular wheel reversing mechanism moves with the incomplete external gear. When it encounters the incomplete internal gear, the driven wheel rotates clockwise to move the wrap film upward with the screw, and then the triangular wheel reversing mechanism will encounter the downward gear is not completely internal. At this time, the driven wheel rotates counterclockwise, so that the plastic wrap moves downward with the screw. This mechanism completes the upward wrapping and the downward wrapping of the cling film, ensuring the complete packaging of the root of the seedling.

3.3. The process of cutting the cling film

During the movement, the film column and the film column fixed on different incomplete gears do not move at different speeds. At the end of the packaging, the two columns just reach the same position to realize the cutting of the plastic wrap, and the film column will be A new cling film is reattached to the solid film column for subsequent packaging of the film.

4. The Typical institution check calculation

4.1. The design calculation of four-bar mechanism

According to the size and positioning requirements of the selected workpiece, we set the center of the bottom plate as the coordinate origin, and the distance of the drive shaft from the center is 225mm. We refer to the design of the power transmission of the sewing machine foot, and the adult foot stroke is 15cm. The design needs to determine the eccentricity of the offset crank slider, the length of the link, and the distance at the other end of the pedal.

In order to facilitate the calculation and analysis, we decompose the six-bar mechanism of the pedal power transmission, and decompose it into an offset crank slider mechanism (the slider is the active member), and the lever member. The specific decomposition process is as follows
The calculation process is as follows:
- When the eccentricity of the machine is 28mm curved surface, \( T = 89.158 \text{mm} \);
- When the eccentricity of the machine is a curved surface of 30 mm, \( T = 239.121 \text{mm} \);
- When the eccentricity of the machine is 40 mm, \( T = 350.212 \text{mm} \).

From the above data, it can be seen that the stroke of the crank is \( L \geq 80 \text{mm} \). Considering the manufacturing and processing error, \( L \) takes 300mm. Considering the thickness and machining error, the eccentricity is taken as \( e = 80 \text{mm} \), and the extreme angle is \( \theta = 12.3547^\circ \). The crank length \( a \) is 66.13mm, and the length of the connecting rod is 472.896mm. Since the crank length is relatively short, the eccentric wheel is used for design, and the eccentric distance is 33.2mm.

We simplified the four-bar mechanism according to the existing conditions, with two points of AD as the fixed point, the length of the rocker is 300mm, the stroke coefficient ratio \( K \) is equal to 1, and the length of the rod is calculated. According to the calculation, the crank length is 66mm. The connecting rod is 473, the pole angle is 1.23 deg, and the maximum transmission angle \( r \) is 65 degrees. Polar characteristics as shown below.
4.2. The design calculation of timing belt

We roughly estimate the rated output power:

\[ P = T \cdot \omega = 4.8 \times 0.1 \div 0.067 = 7.16 W \]  \( \text{(1)} \)

The coefficient of work we take is: \( K_i = 1.7 \)

Then calculate the power:

\[ P_{in} = K_i \cdot P = 7.16 \times 1.7 = 12.17 W \]  \( \text{(2)} \)

Calculate the pulley speed:

\[ n = \nu / r = 0.1 \div 0.067 \times 60 = 8.96 r / \text{min} \]  \( \text{(3)} \)

Therefore, select H-belt, pitch: \( P_b = 12.7 \text{mm} \)

Select the number of active gear teeth as: \( z_1 = 41 \)

Small pulley pitch diameter

\[ d_1 = \frac{z_1 P_b}{\pi} = \frac{41 \times 12.7}{3.14} = 165.82 \text{mm} \]  \( \text{(4)} \)

The number of large belt teeth is: \( z_2 = 29 \)

The pitch is: \( P_b = 12.7 \text{mm} \)

The belt speed is calculated as follows:

\[ v = \frac{\pi \ln}{60 \times 1000} = \frac{3.14 \times 117.29 \times 8.96}{60 \times 1000} = 0.1 m / \text{s} \leq v_{\text{max}} \]  \( \text{(5)} \)

Initial interval between weeks: according to the formula

\[ 0.7(d_1 + d_2) \leq a_0 \leq 2(d_1 + d_2) \]  \( \text{(6)} \)

Inferred

\[ 232 \text{mm} \leq a_0 \leq 663 \text{mm} \]  \( \text{(7)} \)
Timing belt length calculation:

\[ L_0 = 2a_n + \frac{\pi}{2}(d_1 + d_2) = 2 \times 465 + \frac{3.14}{2}(165.82 + 165.82) = 1720.67 \text{mm} \] (8)

4.3. The typical part stress analysis

Based on the structure of the device, we analyze the force of the typical force-using parts using software. The analysis results are shown in the following figure:

![Bottom plate force analysis diagram](image1)

**Figure 8.** Bottom plate force analysis diagram

![Support plate force analysis diagram](image2)

**Figure 9.** Support plate force analysis diagram

5. The innovation points

(1) Functional innovation: The artificial power semi-automatic seedling packaging machine of this device is suitable for the development of the current seedling packaging industry. The packaging process existing in the existing seedling packaging is complicated, takes a long time, and requires a lot of manpower operations, etc. The plastic film winding, carton protection and other seedling packaging technology, designed a packaging device suitable for seedling network operators, to achieve rapid winding packaging of seedlings.
(2) Institutional innovation: This device uses the timing belt, offset crank slider mechanism, incomplete gear mechanism and other mechanisms to realize the integration process of power transmission, seedling positioning and winding packaging.

6. The application prospects
Today, with the rapid development of the Internet, network operators are also showing a blowout. Among them, the nursery stock network operator. The development prospects of the seedling industry are huge and can be called the sunrise industry. During the transportation of seedlings, if the seedlings are exposed to the sun and are hit by the wind for a long time, the seedlings will lose too much water, the quality will drop, and even die. Therefore, minimizing the loss of water during transportation can greatly increase the survival rate of seedlings, which puts high demands on the packaging and transportation of seedlings. The current seedlings are packed in many steps, the process is cumbersome, and a lot of manpower and material resources are consumed, which hinders the rapid development of the seedling industry to some extent.

Compared with the existing manual seedlings of the network nursery operators, the artificial power semi-automatic seedling packaging machine can improve the packaging, sealing and shipping efficiency of the seedlings through semi-mechanized and standardized methods, and it is convenient to complete the goods in the fastest time. The processing of order delivery process meets the requirements of fast and convenient Internet e-commerce requirements, which is conducive to the existing seedling network dealers to develop the network market and improve the efficiency of commodity circulation. It can effectively solve the problem of large workload and small number of employees in the initial stage of the online store. The problem has good marketing value and economic benefits.

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