Study on Manufacture of Production Line and Characteristics of Rice Straw Seedling Trays

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Abstract

As the late processing of rice straw may consume the cost and pollute the environment, this paper put forward a method to use the rice straw, namely, the rice straw is used as the raw material for making seedling trays. The process of seedling tray production was designed, and the method of obtaining raw materials and steps of seedling tray production were introduced. In addition, the overall structure, transmission system and the forming mold of the pneumatic molding machine were also designed and produced. Next, the seedling trays were made by using the production line to analyze the characteristics of the rice straw seedling strays. The study was intended to explore the rules about the influence of moisture content on the characteristics of the seedling strays. As the moisture content of the seedling trays increased, the seedling trays expanded, increasing the volume, density and mass. However, the ultimate tension and shear force borne by the seedling stray decreased along with the increase of moisture content. It could be known from the analysis that: rice straw seedling trays could satisfy the needs of rice nursery. Compared with the traditional plastic seedling tray, the rice straw seedling tray can simplify the production process and provide natural nutrients for rice seedlings.

Keywords: *Rice straw, straw utilization, plant seedling trays, production line design, manufacture, characteristics of seedling strays*

I. Introduction

Rice is one of the major food crops in the world. China is the world's largest country of rice production and it is also a big producer of straw, with an annual output of about 1 billion tons of straw [1]. The best way to deal with straw is to return it to the farmland, which not only protects the land from some natural disasters but also ensures soil nutrients. Although many experts and scholars have studied the straw mulching devices, more than 50% of the straw cannot still be returned to the farmland for various reasons [2-4]. At present, the waste straw is mainly disposed as follows: baling, power generation, animal feed, etc. These methods can increase the utilization rate of straw to a certain extent, but the number of waste straw is still very large [5]. Therefore, expanding the comprehensive utilization of straw can not only realize waste utilization and solve the problems existing in the waste straw utilization, but also play a positive role in reducing the purification cost of straw burning and reducing environmental pollution.

This paper put forward a method to use the rice straw, namely, the rice straw is used as the raw material for making seedling trays. At present, there are mainly two ways of transplanting rice seedlings: direct rice seedling transplanting as well as seedling cultivation and then transplanting. In China, the method of seedling cultivation and transplanting is mainly used in rice production. The rice seedling cultivation is an important production link, and the rice seedling tray is the basic operation tool in this link. In recent years, many Chinese scholars have explored the

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production and molding mechanism of straw seedling trays. Wang Chun et al. [6-8] put forward the concept that the nutrient hole tray of rice straw, and developed the hole tray molding machine, precision seeder and planter that match the nutrient hole trays. They also established a system for the rice potting cultivation technology in the conditions of the common rice cropping management. The nutrient hole trays mainly made of rice straw are used to replace the plastic hole trays, which realizes the mechanized farming of rice potting cultivation. The nutrient hole trays of rice straw could cultivate the pot seedlings with tillers. As rice grows, hole trays slowly degrade in the farmland, realizing the goal of rice straw returning to the farmland and expanding the current uses of rice straw. The application of the developed nutrient hole trays in the production practice could meet the agronomic requirements of the potting cultivation production. However, the raw materials of the hole trays are composed of straw, paper pulp, adhesives, cow dung and water after rice is crushed, so it is the liquid raw material and is anisotropic. The gas-solid-liquid coupling system and the molding adsorption mechanism about the preparation of the nutrient rice straw hole trays and the structure of the pneumatic adsorption molding machine are still unclear, so some problems still exist in the bulk production such as the uneven thickness and the low molding stability of hole trays, which requires further improvement. Shi Hongzhi, Zhu defeng, Xing Chunqiu et al [9-10] studied the influence of different seedling amount on the quality and characteristics of the mechanically transplanted rice seedlings as well as the output in the biodegraded hole trays. The results showed that the mechanical transplanting along with hole trays could give full play to the advantages of cultivating seedlings through sparse seeding, improve the quality of mechanical transplanting, and facilitates the sparse transplanting of hybrid rice. In addition, the yield-increasing potential could be fully achieved and completely degrade within a week. Previous studies have also been conducted in the field of the liquid molding. Liao Zeshun and Lian Guangjun et al. [11-12] successively completed the optimization of the pulp adsorption hole structure in the pulp suction and filtration forming mold through ANSYS/FLOTRAN simulation analysis software and experimental research. This revealed the key factors to influence the suction and filtration molding efficiency of paper molded products. Zhang Zengmeng and Zhou Hua et al. [13] established the simulation model for the mold-filling flow in water-assisted injection molding. Helena Nilsson and Shahrzad [14-15] simulated the hydrodynamic characteristics of the system in the slurry adsorption molding process. Akira and Surendra S et al. [16-17] adopted the grouting molding technique and the mold was equipped with vacuumed holes and heating elements. Yoshiaki[18] adopted the slurry suction molding method, and the bottle-shaped cavity of the mold was horizontally immersed in the slurry pond, which can effectively avoid the uneven thickness of products, and the bottle shaped cavity of the forming mold was immersed in the slurry pool in a horizontal posture, which could effectively avoid uneven thickness of the products. Nissei [19] proposed and developed a blow-molding device. Alireza[20] used the finite element software ABAQUS to simulate the forming process of high-speed blowing molding technology, and proposed an off-line heating cycle plan with the minimum temperature distribution difference and the shortest processing time. Horng-Yu Wu and G. Mitukiewicz [21-22] both proposed the use of high temperature gas in the forming of the blow molding technology, and carried out numerical simulation by using the shortened molding time as an index.

Based on the research above, this paper designed a production line of seedling trays by using rice straw as the raw material. And then this paper introduced the specific methods about the obtaining, processing and molding of straw, and it also designed the seedling tray molding machine. The production line was used for the production of seedling trays, and the characteristics of straw seedling trays were analyzed. It verified the feasibility of straw seedling strays in the actual production.

II. Production Procedures of the Seedling Strays Made through Plant Potting Cultivation

The production procedures of the plant seedling strays mainly include two parts: the obtaining and transportation of rice straw as well as the industrial production line of the seedling trays. In the farmlands, the all-in-one machine of rice harvest and baling is used to collect rice straw for raw production materials. Bundles of rice straw in the farmlands is transported to the production line. The production is mainly made up of impounding reservoir, pulp stirring machine, storing pool, pulp pump, screening machine, fiberizer, molding machine and drying chamber. The production line of the plant seedling trays is shown in Fig 1.

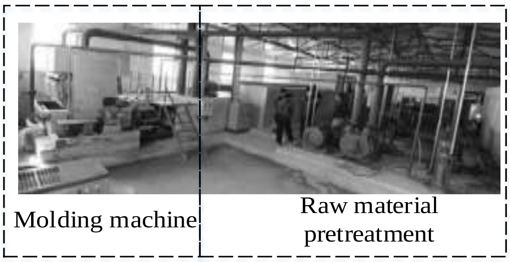


Fig 1: Production line of the plant seedling trays

With the vacuum adsorption force, the solid substances of the slurry were adsorbed on the surface of the mold, which formed the blastoderm. The blastoderm was extruded, formed and then placed on the conveyor belt by using the mold suction roller and the mold extractor together. After that, it was conveyed to the drying chamber and went through 4 steps including preheating, convection drying, countercurrent drying and cooling to realize the high temperature disinfection and drying. Finally, the prepared rice straw seedling trays were sorted out, packed and transported. The manufacturing technique and production line of the rice seedling trays are shown in Fig. 2 and 3.

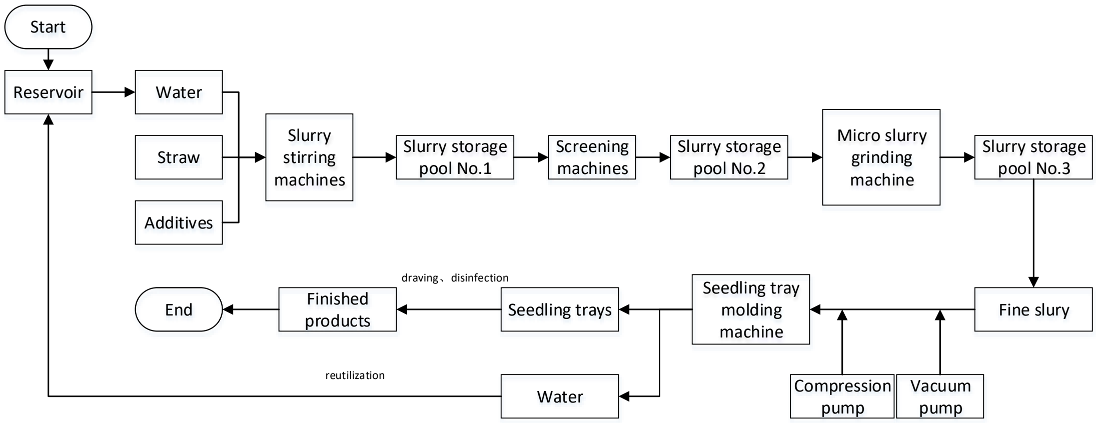


Fig. 2: Seedling tray production technique

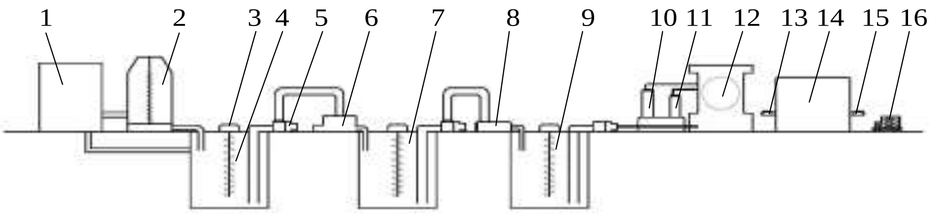


Fig 3: Sketch drawing of the seedling tray production line

1. reservoir 2. slurry stirring machine 3. agitator 4. Material storing pool No.1 5. slurry pump 6. screening machine 7. slurry storing pool No.2 8.slurry grinding machine 9. slurry storing pool No. 3 10. Compression pump 11. vacuum pump 2. Molding machine 13. Conveyor belt 14. Drying chamber 15. Finished products of seedling trays 16. Carrier vehicles

III. Design of Pneumatic Molding Machine

3.1 Overall structure

The molding machine of straw seedling trays is the core device of the production line, and its performance directly affects the quality of seedling trays, so the overall structure and key components of the molding machine were designed. The molding machine adopts pneumatic molding, which uses the positive or negative pneumatic pressure to mold products. The positive pressure and negative pressure are usually realized by compressed air and vacuumized air, respectively. The molding parts of some molds (terrace die and die) are replaced by the role of gas to realize the shape. Therefore, simple molding equipment can be used to obtain molding parts of large sizes. Based on the principle of pneumatic molding, the molding machine of the nutrient rice straw hole trays was designed. The molding machine is mainly composed of motor, reducer, transmission system, mold extractor, slurry storage pool, suction molding roller, shell, etc. as shown in Figure 4.

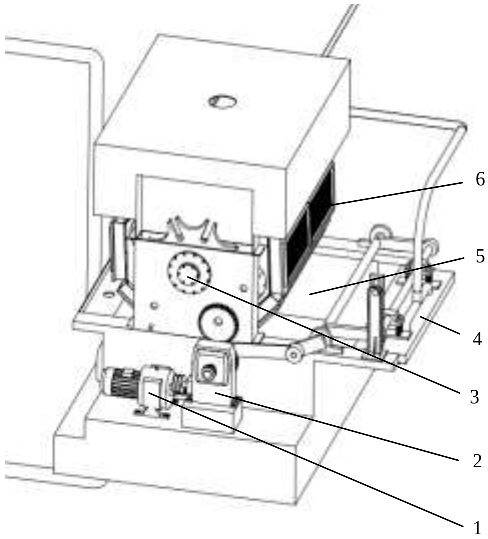


Fig 4: Rice seedling tray molding machine

1. motor 2. Reducer 3. transmission system 4. mold extractor 5. slurry storage pool 6. mold suction roller

3.2 key component design

The transmission system is mainly made up of reducer, eccentric gear, grooved wheel mechanism, connecting rod mechanism, internal groove guide rod and cylindrical sliding block. The transmission system is composed of two transmission lines. In one transmission line, the rotating speed of the motor is transformed into the desired circular movement of the mold suction roller by using the eccentric gear and the groove wheel mechanism so that it completes the suction molding and pressure shaping link. In the other one, the rotating speed of the motor is transformed into the periodic oscillations of the mold extractor through the connecting rod mechanism, the longitudinal internal groove guide rod and the cylindrical sliding block.

The forming die is a key part of the hole tray molding machine. The quality of the mold directly determines the forming effect of the hole trays. The vacuum forming die is mainly composed of template, pneumatic panel, distribution chamber, ventilation pipe, sealing strips, depression bars, etc., as shown in Fig. 5. The template is composed of convex template and concave template. The convex template is the forming template and the concave template is the mold taking formwork. The shapes of the two templates are respectively corresponding to the four convex surfaces of the hole tray and can mesh with each other. When the ventilation pipe of the mold is connected with vacuum pump, the distribution chamber is vacuumized. The negative pressure is formed in the chamber. The uniformly distributed ventholes of the pneumatic panel distributes the air flow to the template. Meanwhile, the vacuum adsorption force adsorbs the solid substances of the slurry onto the template surface, forming the blastoderm. After maintaining the pressure for some time, the assistant mold driven by the transmission mechanism removes the blastoderm through the adsorption affinity and completes the forming process of the hole trays.

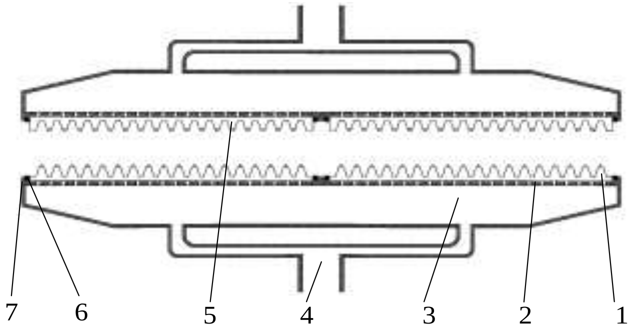
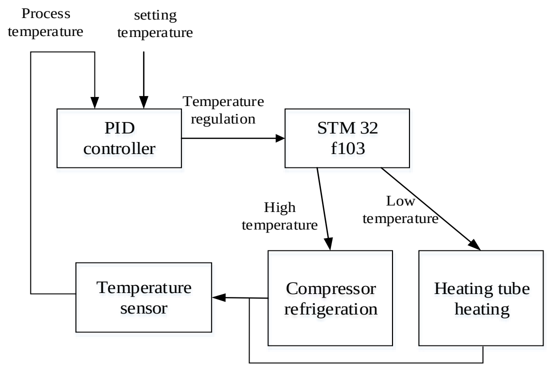


Fig 5:Vacuum forming die

1. convex template 2. pneumatic panel 3. distribution chamber 4. ventilation pipe 5. concave template 6. depression bars 7. sealing strips

The sizes of seedling trays need to be designed according to the properties of seedling tray materials in order that the straw seedling trays can meet the working requirements of the transplanting machines and tools. Based on them, the dimensions of the convex and concave dies are designed. Given that the straw seedling trays are made up of 30% straw, 20% cow dung and 20% adhesives, this paper analyzed the characteristics about how the moisture content changes along with the environment between straw seedling trays and plastic seedling trays. The plastic dimensions don’t change along with the changes in the moisture content of the environment, while the materials of straw seedling trays have a certain hygroscopic expansion. The hygroscopic expansion rate is an important physical and chemical index. It reflects the product's properties including water resistance, dimensional stability, strength, etc. In order to explore the expansion characteristics of plant mixture materials, the related experiments were carried out. During the test, the measured material was immersed in the constant temperature water tank, and the temperature of the water tank remained at (20±1) ℃. A refrigeration device (compression refrigerator) and a heating device (heating tube) were placed in the water tank with the purpose of heating when the water temperature is low and cooling when the water temperature is high. STM 32F103 was selected as the main control chip of the controller. The constant temperature control part adopts anti-integral saturated PID control system to prevent the phenomenon of temperature shock and improve the control precision. The thermostatic control diagram is shown in Figure 6.



During the test, the mixed material of the cube (side length of t1: 10mm) was placed in the water tank. Before immersion, the center points of all the specimens (the diagonal intersection points of the specimens) were first marked and their thickness was measured. After immersion, the specimens were taken out, and the water attached to the surface was quickly wiped away. Meanwhile, the side length of the specimen after immersion was measured at the original measuring point. The hygroscopic expansion of the specimen is shown in Fig.7, and the expansion rate T is calculated according to Formula 1:

$$T = \frac{t_2 - t_1}{t_1} \times 100\% \tag{2}$$

In the formula, T - hygroscopic expansion rate, %

T1 -- the side length of the specimen before immersion, mm

T2 -- the side length of the specimen after immersion, mm

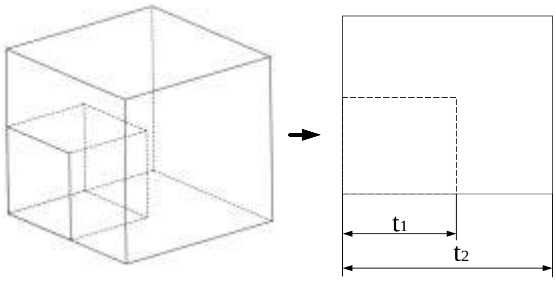


Fig 7: Diagram of straw seedling tray material expansion

The initial moisture content of the seedling tray mixture was 3±0.2%. The moisture content of the seedling soil was 20±2% when the moisture content of the specimen reached that at the end of sprout cultivation after being immersed in water. A total of 50 groups of side length changes were collected to obtain their average value. Finally, the hygroscopic expansion rate was 2.14%.

The dimensions of seedling trays are designed by using the hygroscopic expansion rate for reference. At present, the lateral size of a single transplanter is 285mm in the market. In this study, 280mm was used as the standard for calculation. Considering that the number of seedling separation is mostly 18 times in the commonly used transplanters in the market now. In order to meet the requirements of the universality of the hole trays, the existing structure of the hole trays is referred to, and the total number of the holes is 18 in each transverse row of the seedling trays. Meanwhile, the shape of the hole is square opening. As the overall shape of the hole tray is rectangular, the sectional shape of the hole is finally determined to be a rectangle with a short transverse side and a long longitudinal side in order to evenly distribute the holes and fully use the space resources of the hole trays.

The forming of the hole trays depends on the mold. The demolding slope of the mold determines the difficulty of demolding and the forming effect after demolding. The commonly used slope range is 1~4°. Because the large demolding slope not only makes it easy to demold, but also can improve the uneven degree of the wall thickness in the molded parts. The demolding slope is set as 4° in this study, as shown in Figure 8. According to the trigonometric function relationship, it could be determined that: at the lower end of the hole, the transverse side length is 10mm, the longitudinal side length is 12mm, and the depth of the hole is 14mm. According to the above parameters and Formula 2, the volume of the hole is 365.57mm3, which meets the requirements of rice seedling cultivation volume.

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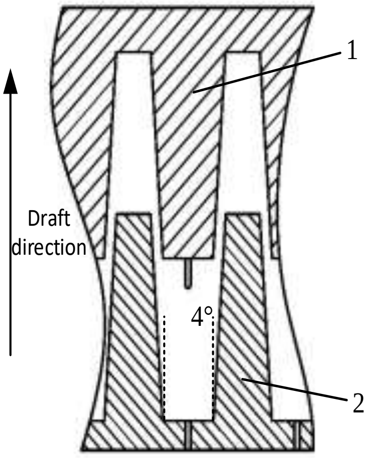

Fig 8: Hole tray demolding process
1. mold 2. hole tray

$$v = \frac{6[l_x \cdot l_x^{'} + l_y \cdot l_y^{'} + (l_x + l_y)(l_x^{'} + l_y^{'})]}{h} \tag{2}$$

In the formula, V - hole volume, mm3;

lx - transverse length at the upper end of the hole, mm;

ly - longitudinal length at the upper end of the hole, mm;

lx '-- transverse length at the lower end of the hole, mm;

ly '-- longitudinal length at the lower end of the hole, mm;

h -- hole depth, mm.

The base thickness design should meet the following three requirements. First, the base of hole trays could facilitate the effective packing in the autotrophic stage of seedlings. Second, the base could ensure that the principal root can absorb the nutrients of the seedbed soil in the heterotrophic stage. Finally, the base won't affect the follow-up growth of the seedling root system after being transplanted together with seedlings into the farmlands. The experimental results of the sprout cultivation suggested that: when the base thickness of the hole tray is 2mm, the requirements above could be met. If the number of holes is 18 in each row, the vertical side thickness is computed according to the formula 3. The final vertical side thickness is 3mm.

$$m = \frac{Lx - 18lx}{19} \tag{3}$$

Where, m---thickness at the upper end face of the vertical side, mm;

Lx---transverse dimension of the hole tray, mm;

lx---transverse side length at the upper end face of the hole, mm.

In the design of the longitudinal dimensions, it is required that the geometrical centroid deflection of the hole tray shouldn't be more than 3.6mm, the allowable deflection of the seedling tray so that the hole tray won't overbend or break in the application. The geometrical centroid deflection of the hole tray is calculated according to the formula 4.

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$$yk = \frac{5qL4}{384EI} \leq [y_k] \tag{4}$$

In the formula, yk -- geometrical centroid deflection, mm;

[yk] -- allowable geometric centroid deflection, mm.

q--standard value of average wiring load, KN /m;

L -- the longitudinal size of the hole tray, m;

E -- the elastic modulus of the hole tray, GPa;

I – cross-sectional moment of inertia in the hole tray, cm4.

Based on the analysis of the expansion rate and the seedling tray structure, the design about the shapes of seedling trays and holes are shown in Fig. 9. The number of transverse holes is 34 per row, the number of longitudinal holes is 18 per column, and the total number of holes is 612 in each tray. The detailed dimensions are shown in Table 1.

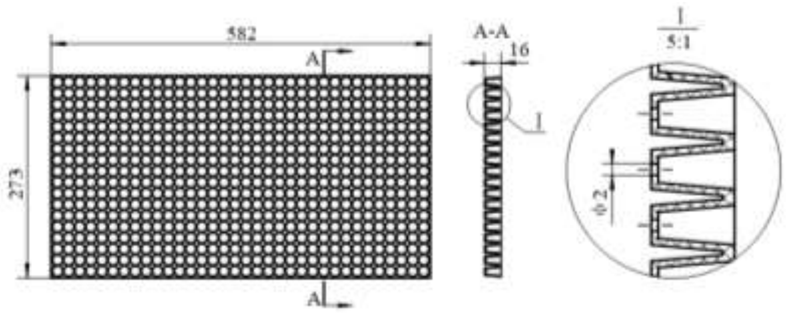

Fig 9: Seedling tray shape and the overall dimensions

Table 1 Parameters of straw seedling trays

item	parameters
transverse dimensions of hole tray /mm	273
longitudinal dimensions of hole tray /mm	581
transverse side length at the upper end face of the hole/mm	12
longitudinal side length at the upper end face of the hole /mm	14
transverse side length at the lower end face of the hole /mm	10
longitudinal side length at the lower end face of the hole/mm	12
thickness at the upper end face of the vertical side/mm	3
thickness at the lower end face of the vertical side/mm	5
base thickness/mm	2
hole depth/mm	14
venthole diameter/mm	2

total number of transverse holes /holes	18
total number of longitudinal holes /holes	34
total number of holes / holes	612

The distribution system needs to ensure the even and uniform air pressure in each seedling mold. When the mold rotates to the mold extraction position, the mold is connected with the air compression pump to eliminate the negative pressure in the chamber so that the mold extractor can take and place the blastoderm. The way is simple and compact in structure and makes congestion less likely to happen. The demolding and delivery of the seedling tray is determined by the negative pressure of the air chamber in the mold, and the pressure is adjusted by the air compression pump.

The air compressor compresses the air by using the reciprocating motion of the piston in the cylinder. Regardless of sizes, most air compressors generally use other power to drive the crankshaft rotation of the crankcase. The crankshaft drives the reciprocating motion of the piston in the cylinder through the connecting rod. When the piston moves down, the volume of the cylinder becomes larger and the pressure in the cylinder becomes smaller. The air is sucked into the cylinder through the intake pipe. When the piston moves up, the intake pipe closes and the volume of the cylinder becomes smaller, so the air is compressed from the exhaust passage into the air cylinder.

The working circuit of the air conditioning compressor is divided into the evaporation area (low pressure area) and the condensation area (high pressure area). The indoor and outdoor units of the air conditioning belong to the low-pressure or high-pressure area, respectively (depending on the working state). When the refrigerant flows from the high-pressure area to the low-pressure area, and is ejected to the evaporator through the capillary tube, the pressure drops sharply and the liquid refrigerant immediately becomes gas. In the process, a lot of heat in the air is absorbed through the radiator fin. The air conditioning compressor continues working, with the heat at one end of the low-pressure area continues being first absorbed into the refrigerant and then sent to the high-pressure area. Finally, the heat is diffused into the air, playing a role in regulating the temperature.

3.3 Working process and forming principle of the forming machine

The working process of the seedling tray forming machine is as follows. The raw material of rice straw is mainly used to prepare the slurry. The slurry is stored in the slurry storage pool which is equipped with feedstock pipe and overflow pipe. By controlling the flow speed of both feedstock pipe and overflow pipe, the slurry is kept at a proper height to ensure that the main mold of the mold suction roller could be immersed in the slurry at the lowest position. After the forming machine starts working, the rotating speed of the motor is transformed into the desired motion of the mold suction roller and the oscillation of the mold delivery device through two transmission lines. Driven by the mold suction roller, the main molds are immersed in the slurry of the pool in succession. Under the action of the vacuum pump, the solid substances in the slurry are uniformly adsorbed on the surface of the convex template with a fixed thickness, forming the blastoderm in the shape of hole trays. Moreover, the adsorbed blastoderm is conveyed to the front of the forming machine for the mold delivery. The mold delivery device makes the periodic oscillation between the mold suction roller and the conveyor belt. When the mold delivery device moves to the right front of the mold suction roller, the main mold of the mold suction roller produces the air-blowing force under the action of the air compressor, while the assistant mold of the mold delivery device produces the adsorption force under the action of the vacuum pump. Influenced by the two kinds of forces, the blastoderm shifts from the mold suction roller to the mold delivery device. When the mold delivery device moves above the conveyor belt, the vacuum pump stops working and the air compressor starts. At this time, the air-blowing force is generated on the surface of the assistant mold, separating the blastoderm from the template and delivering it to the surface of the conveyor belt. The demolding process is completed. The sketch drawing about the working process of the adsorption molding is shown in Fig. 10.

As shown in Fig. 11, the actual operation process is divided into four steps: 1. The integral forming mold is immersed

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in the slurry tank, and the solid substances in the slurry are adsorbed on the surface of the mold through negative pressure suction. The mold carrying the adsorbed substance rotates counterclockwise to a horizontal position of 90°. 2. The auxiliary mold moves linearly to the overall forming mold. After extrusion, the hole tray is adsorbed to the auxiliary forming mold through negative pressure. 3.The auxiliary forming mold returns to the original position. 4. The auxiliary forming mold rotates by 90° into a vertical position and then drops onto the loading platform 4 through the blowing force and gravity of the hole tray itself. The production of a hole tray is completed.

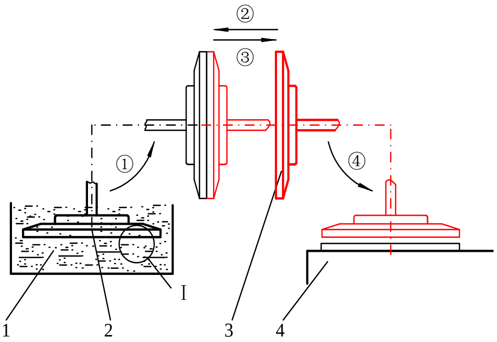

Fig 10: Sketch drawing of adsorption forming working process

1. slurry tank 2. overall forming mold 3. auxiliary forming mold 4. loading platform

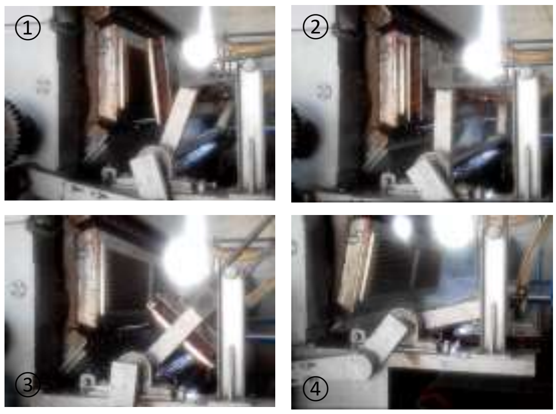

Fig 11: Actual operation process

The forming principle of the seedling tray is as follows. The mold is first immersed in the slurry prepared through rice straw, and then the mold chamber is vacuumized through the vacuum pump, forming the negative pressure in the chamber. The distributed ventholes on the pneumatic panel evenly distributes the air flow to the template. The vacuum adsorption force causes the solid substances of the slurry to be adsorbed to the surface of the template, which forms the hole trays. The air and water in the mold cavity are discharged from the mold through the pipeline. The forming principle is shown in Fig. 12.

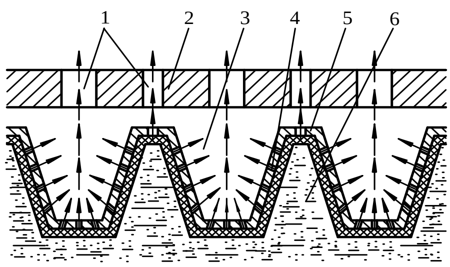

Fig 12 Adsorption forming principle

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1. ventholes 2. pneumatic panel 3. forming cavity 4. suction hole 5. connecting panel of earthen bowls 6. Slurry

IV. Seedling Tray Characteristic Analysis

Regarding the seedling trays without rice seedlings transplantation and those in various stages of the sprout cultivation, the moisture content is measured respectively. In the initial forming stage of the seedling trays, the moisture content was 2.5%~3.5%. From the initial stage of rice seedlings to the stage of finally grown seedlings, the moisture content was 3.5%~35%. The seedling growth process is shown in Fig. 13.

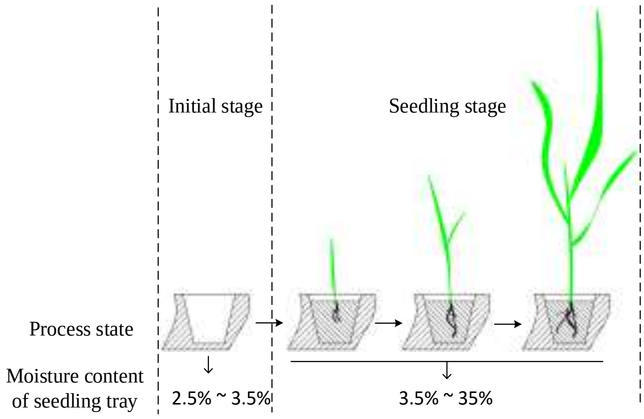

Fig 13: Seedling growth process

The external water changes can not affect the characteristics of plastic seedling trays, but straw seedling trays are easily affected by moisture content because of the raw material. Therefore, the influence of moisture content on the characteristics of seedling trays was explored. The changes in the mass, volume and density of the seedling trays were recorded at 5 different moisture content rates in the experiment and the curve was shown in Fig. 14.

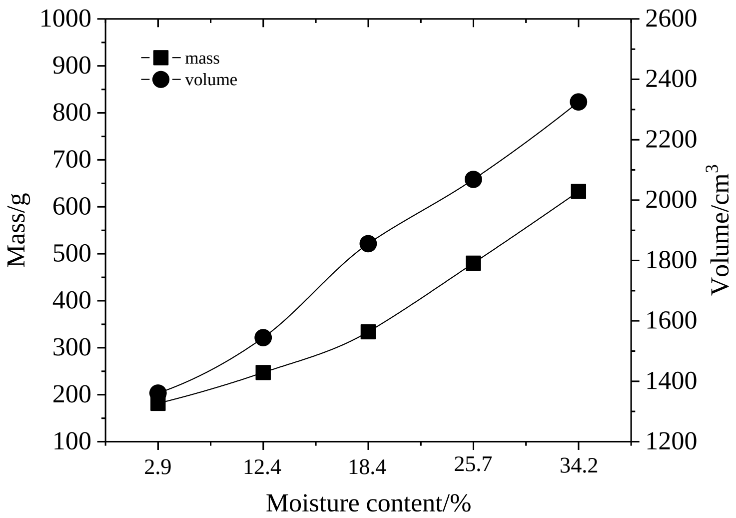

Fig 14: Curve about the changes in the mass and volume of seedling trays along with moisture content

As the moisture content increased, the seedling tray expanded because of water absorption. Therefore, the volume kept increasing and the overall triaxial dimensions of the seedling tray also increased gradually, but the triaxial dimensions of the hole decreased gradually. When the moisture content is 2.9%, it means that the basic moisture content of the potting seedling tray that was dried and stored for one year. In this condition, the potting seedling tray has less wet basis and free water. Moisture mainly comes from the bound water in the raw material composed by straw, slurry, etc., so the seedling tray has a smaller tenacity. When the moisture content of the potting seedling tray is 18.4%, the total length of the seedling tray increases by 27mm compared with that of the initial moisture content rate, with a change rate of 4.6%. The hole length decreases by 0.9mm with a change rate of 6.9%. The total width of the seedling tray increases by 12mm with a change rate of 4.4%. The hole width decreases by 0.8mm with a change rate of 7.2%. The height of the seedling tray increases by 1mm with a change rate of 6.25%. The hole height increases by 0.9mm with a change rate of 0.67%. When the moisture content of the potting seedling tray is 34.2%, the total length of the seedling tray increases by 51mm compared with that of the initial moisture content rate, with a change rate of 8.7%. The hole length decreases by 2mm with a change rate of 15.3%. The total width of the seedling tray increases by 18mm with a change rate of 6.6%. The hole width decreases by 2.1mm with a change rate of 19%. The height of the seedling tray increases by 1.5mm with a change rate of 9.37%. The hole height increases by 1.3mm with a change rate of 9.6%.

The intensityof the seedling tray is an important index to measure the quality, so this paper explored the tension borne by the seedling tray under different moisture content and the shear force of the seedling needle used for cutting off the seedling tray. The test equipment is CTM2050 micro-control electronic universal testing machine, the mechanical sensor model is S9M, and the maximum range is 50Kg. The curve about the changes in tension and shear force under different moisture content is shown in Fig. 15.

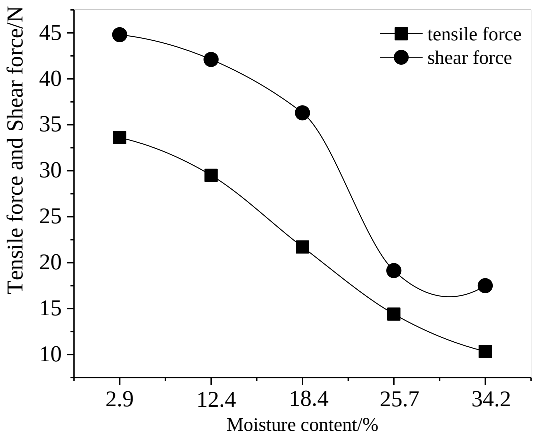

Fig 15: The curve about the changes in tension and shear force under different moisture content

As the moisture content increases, the tension and shear force borne by the seedling tray gradually decreases. When the moisture content is 2.9%, the tension and shear force borne by the seedling tray is 33.6N and 44.8N, respectively. When the moisture content is 34.2, the value drops to 10.3N and 17.5N, respectively. The intensity of the seedling tray decreases as the moisture content increases, which not only satisfies the intensity requirements of the seedling tray in the initial stage of sprout cultivation but also reduces the working load in the later transplantation when the seedling tray is not scattered.

V. Discussion

The traditional plastic seedling tray is compared with the plant seedling tray. In terms of the production process: when the traditional plastic seedling tray is used for seedling cultivation, the soil needs to be separated from the seedling tray in transplantation. It makes the mechanized operation hard and mainly depends on the human labor. When the plant seedling tray is used for seedling cultivation, the base of the fully grown seedling tray basically softens. Therefore, it can save the separation of the soil from the seedling tray and simplify the operational process. According to the characteristics of the plant seedling tray, it could be known that: with the moisture content of the seedling soil in transplantation, the seedling tray bears less shear force and makes transplantation easier. As the plant seedling tray is made of rice straw, the base straw could provide natural nutrients for rice seedlings after being transplanted to the farmlands.

VI. Conclusions

To improve the comprehensive utilization rate of the waste straw and provide a method for dealing with it, rice straw was used as the raw material to prepare a kind of rice seedling trays in this study. Meanwhile, the production line of plant seedling trays was established, and the overall structure and key components of the pneumatic forming machine was designed. Finally, the characteristics of the plant seedling trays were analyzed.

(1) The plant seedling trays are made up of rice straw, cow dung, adhesives, etc., and the material has the property of hygroscopic expansion. The tested expansion rate was 2.24%. Based on this, the dimensions of the plant seedling trays and the forming mold were determined.

(2) The seedling trays expanded because of water absorption, and the intensity decreased along with the increase in the moisture content. The intensity of seedling trays could not only satisfy the needs of rice seedling cultivation but also ensure that the operational machines could work smoothly in transplantation when the seedling trays were complete without being scattered.

(3) Compared with the traditional plastic seedling trays, it is unnecessary to separate the seedlings from the soil when the plant seedling trays are used for seedling cultivation. This simplifies the production process. In transplantation, the shear force borne by the plant seedling tray is relatively small, so no extra working load will be increased. In addition, plant seedling trays can degrade in soil and transform into nutrients, which provides natural nutrients for soil and rice seedlings.

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