

DESCRIPTION

METHOD AND DEVICE OF FILM STEPLESS BIAXIAL TENSION BASED ON SADDLE-SHAPED SURFACE TRANSITION

FIELD OF THE INVENTION

The present invention relates to the field of polymeric material processing technology, particularly a method and device of film stepless biaxial tension based on saddle-shaped surface transition.

BACKGROUND OF THE INVENTION

Using the biaxial tension technology to produce plastic film can improve the mechanical properties of the film, reduce the permeability to gases, water vapor, etc., enhance transparency, surface gloss and other optical properties of the film, narrow the thickness deviation, and improve the dimensional uniformity.

Currently, the processing technology of producing the biaxial tension film can be divided into two categories: A double-bubble method and a stentering processing method. By the double-bubble method, the materials are melted and extruded by an extruder to form a primary film before being quenched, and are then heated and subjected to the second inflation tension to produce a thin film product. The stentering method of producing and processing the biaxial tension film includes stepwise tension and synchronous tension. With the stepwise tension technology, the longitudinal tension is achieved by a roller with different linear velocity, and the

lateral tension is achieved typically by two sets of clamps that clamp the film to move along a guide rail having a set track. However, the stepwise tension film is subjected to a force nonuniformly, and has nonuniform thickness, a large thermal shrinkage rate, poor anisotropy, and poor quality balance.

The German Bruckner company applied a linear synchronous motor to the film synchronous biaxial tension equipment, which used the linear synchronous motor to precisely control the movement speed of the respective clamps on the guide rail, so as to keep high-precision synchronization of the movement of the clamp clamping both sides of the film, thus achieving synchronous biaxial tension of the film. In 2007, the Austrian ANDRITZ company launched a mechanical synchronous biaxial tension technology MESIM, which used a mechanical chain clamp with the telescopic performance to achieve synchronous biaxial tension of the film. An application for a patent for invention No. 201010612820.8 disclosed the plastic film biaxial tension equipment, which was based on the principle of gradually reducing the distance between the inner rail and the outer rail of the tension section front-to-back to change the structure of an M-shaped connecting rod of the outer rail, thereby changing the distance between the clamps in the tension section and achieving synchronous biaxial tension of the film. The invention patent application No. 201310184357.5 disclosed a film synchronous biaxial stretcher based on the principle of using a mechanical clamp to clamp the film to move on a circumferential guide rail so as to achieve synchronous biaxial tension of the film, which is not much different from the traditional mechanical clamping synchronous biaxial tension, except that the linear guide rail was arranged as a circumferential

guide rail.

The film produced by the synchronous biaxial tension has better comprehensive performance than the film produced by the stepwise biaxial tension, but the mechanical clamping synchronous biaxial tension technology has the following problems: (1) Due to nonuniform tension, the film is easy to produce a serious bowing phenomenon, which will lead to different molecular orientation of the central and edge parts of the film, as well as different optical properties, permeability and thermal shrinkage rate of the film; (2) the clamps in the clamp assembly are distributed at an interval, and the film stretching process is intermittent tension instead of infinite tension; (3) the clamps in the clamp assembly are distributed as points, and the edge of the film is subjected to a force nonuniformly in the stretching process, with the stretched film nonuniform in thickness and easy to break, not allowing large-angle tension; (4) the clamp assembly itself is complicated in structure and easy to be damaged, and has high production cost; (5) the mechanical clamping synchronous biaxial tension technology has a poor synergistic effect, has relatively high requirements on the basic process, and is demanding for the accuracy of the rail, the motor drive and the control system, resulting in high cost of the film production line.

For the above problems of the present film biaxial tension method and equipment, it is of great significance to develop a new type of film synchronous biaxial tension equipment.

In order to overcome the defects of the prior art, a purpose of the present invention is to provide a film stepless biaxial tension method based on saddle-shaped surface transition that is simple in principle, easy to control and excellent in the comprehensive performance of the film.

Another purpose of the present invention is to provide a film stepless biaxial tension device based on saddle-shaped surface transition for implementing the above method.

A technical solution of the present invention is as follows: The present invention provides a film stepless biaxial tension method based on saddle-shaped surface transition that, in the film surface biaxial stretching process, applies the lateral and longitudinal tensile forces respectively to a different tangent plane, so that the film is subjected to smooth transition in a three-dimensional space from a narrow plane via a saddle-shaped surface to a wide plane, with the thickness uniformity of the biaxial tension film regulated by controlling the shape of the saddle-shaped surface.

The present invention provides a film stepless biaxial tension device based on saddle-shaped surface transition for implementing the above method, which comprises a herringbone wheel unit and a parallel wheel unit, the angle between the two lateral tension wheels in the herringbone wheel unit being adjustable, the two longitudinal tension wheels in the parallel wheel unit being arranged in parallel; a binding rope is used to bind the left and right edges of the film to the circumferential surface of the lateral tension wheel and the longitudinal tension wheel; the lateral tension of the film is achieved by the rotation of the lateral

tension wheel, and the longitudinal tension of the film is achieved by the linear velocity difference between the lateral tension wheel and the longitudinal tension wheel. By using the synergistic effect of the binding rope with the lateral tension wheel and the longitudinal tension wheel, the lateral and longitudinal tensile forces are applied respectively to a different tangent plane of the film surface, thereby forming a saddle-shaped surface.

The herringbone wheel unit comprises two lateral sub-units arranged symmetrically, each of which is provided with one lateral tension wheel, with the two symmetrically arranged lateral tension wheels forming a herringbone; the lateral tension wheel is provided at the bottom with a first binding assembly and outside with a first support plate in parallel, and the axle of the lateral tension wheel passes through the first support plate, which is provided vertically at the bottom with an underplate; the underplate is provided at the end near the inlet of the herringbone wheel unit with a fork positioning column, and at the end near the outlet of the herringbone wheel unit with a first outlet positioning column, with a fork arranged at the fork positioning column; the respective forks are connected at the end to a first lead screw through a corresponding inlet nut, and the respective first outlet positioning columns are connected to a second lead screw through a corresponding first outlet nut.

The first binding assembly comprises a first binding rope, a first sliding wheel and a first preloaded wheel, the first binding rope being wound on a plurality of the first sliding wheels and provided outside with the first preloaded wheel; and the axle of the respective first sliding wheels passes through the first support plate.

In the herringbone wheel unit, the angle formed by the ends of the two forks can be adjusted through the first lead screw, and the distance between the lateral tension wheels at the outlet of the herringbone wheel unit can be adjusted through the second lead screw, thereby regulating the outlet width of the film as it is peeled from the lateral tension wheel to achieve the stepless adjustability of the lateral tension ratio, with the angle β between the two lateral tension wheels generally in the range $0^\circ < \beta < 180^\circ$; in the first binding assembly, first the tension of the first binding rope on the first sliding wheel is adjusted by the first preloaded wheel, and then the tightness of the film on the sliding wheel is controlled by adjusting the tension of the first binding rope to ensure that the film is tied tight.

The parallel wheel unit comprises two longitudinal sub-units arranged symmetrically, each of which is provided with one longitudinal tension wheel, with the two symmetrically arranged longitudinal tension wheels arranged in parallel; the longitudinal tension wheel is provided at the bottom with a second binding assembly and outside with a second support plate in parallel, with the axle of the longitudinal tension wheel passing through the second support plate; the second support plate is provided at the end near the inlet of the parallel wheel unit with a guide hole, and at the end near the outlet of the parallel wheel unit with a second outlet positioning column; the respective guide holes are connected with a guide rod, and the respective second outlet positioning columns are connected to a third lead screw through a corresponding second outlet nut.

The second binding assembly comprises a second binding rope, a second sliding wheel and a second preloaded wheel, the second binding rope being wound

on a plurality of the second sliding wheels and provided outside with the second preloaded wheel; and the axle of the respective second sliding wheels passes through the second support plate.

In the parallel wheel unit, the distance between the longitudinal tension wheels can be adjusted through the cooperation between the third lead screw and the guide rod; generally, the distance between the parallel wheels is slightly larger than the distance between the lateral tension wheels at the outlet of the herringbone wheel unit; in the second binding assembly, first the tensiety of the second binding rope on the second sliding wheel is adjusted by the second preloaded wheel, and then the tightness of the film on the sliding wheel is controlled by adjusting the tensiety of the second binding rope to ensure that the film is tied tight.

The principle of the film synchronous biaxial tension device based on saddle-shaped surface control is as follows: In the film surface biaxial stretching process, with the lateral and longitudinal tensile forces acting respectively on a different tangent plane, the film is subjected to smooth transition in a three-dimensional space from a narrow plane via a saddle-shaped surface to a wide plane, with the thickness uniformity of the biaxial tension film regulated by controlling the shape of the saddle-shaped surface; a binding rope is used to bind the left and right edges of the film to the circumferential surface of the lateral tension wheel and the longitudinal tension wheel (that is, the first binding rope binds the left and right edges of the film to the circumferential surface of the lateral tension wheel, and the second binding rope binds the left and right edges of the film to the circumferential surface of the longitudinal tension wheel), the lateral tension

of the film being controlled by adjusting the angle between the two lateral tension wheels, the longitudinal tension of the film being controlled by adjusting the linear velocity difference between the lateral tension wheel and the longitudinal tension wheel; meanwhile the parallel wheel unit can pull the film to both sides in the width direction and flatten and shape it, and only the edge of the film contacts the device in the longitudinal stretching process, with the film surface having no friction damage.

Compared with the current mechanical clamp-type device, the present invention has the following beneficial effects:

1. Under the action of an external force, the film produces continuous synchronous biaxial tension, and forms in the three-dimensional space a saddle-shaped surface similar to the hyperbolic paraboloid. By controlling the shape of the saddle-shaped surface, the present invention can effectively regulate the film bowing phenomenon, thickness uniformity, and microstructure.

2. By adjusting the first lead screw and the second lead screw, the angle between the lateral tension wheels can be changed, thereby adjusting the lateral tension ratio; by using the continuous binding effect of the binding rope on the film and the tensile effect of the herringbone wheel unit, the stepless synchronous biaxial tension of the film is achieved.

3. In the biaxial stretching process, the binding rope is in line contact with the film, thus preventing the edge of the film from being subjected to a nonuniform force in the stretching process due to the gap between the traditional clamps, which is advantageous for improving the thickness uniformity of the film product.

4. In work, the bind rope is always in the same plane, there is no space distortion and other complex deformation, and the width of the binding rope is not restricted; meanwhile, the binding rope does not need to overcome the friction resistance, bears small load, and has a longer life.

5. The binding rope is simple in the winding compression way and running track, the synchronous tension of the herringbone wheel unit is easy to control, and the structure and parts of the device are simple and easy to manufacture and assemble and have relatively low requirements on the basic process, avoiding the issue that the traditional clamp-type tension device is demanding for the accuracy of the rail, the motor drive and the control system and other issues, reducing the cost of the film production line.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of the structure of the film stepless biaxial tension device based on saddle-shaped surface transition, which is in the biaxial tension state at this time.

Fig. 2 is a schematic diagram of the structure of the A-A section in Fig. 1.

Fig. 3 is a schematic diagram of the structure of the film at the herringbone wheel unit forming the saddle-shaped surface.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention will be further described in detail below with reference to examples; however, the embodiments of the present invention are not limited

thereto.

Example:

This example provides a film stepless biaxial tension device based on saddle-shaped surface transition, as shown in Fig. 1, which comprises a herringbone wheel unit and a parallel wheel unit disposed in turn along the film transport direction, the angle between the two lateral tension wheels in the herringbone wheel unit being adjustable, the two longitudinal tension wheels in the parallel wheel unit being arranged in parallel; a binding rope is used to bind the left and right edges of the film to the circumferential surface of the lateral tension wheel and the longitudinal tension wheel, and the lateral tension is achieved while the film is transported forward by the rotation of the lateral tension wheel; the longitudinal tension is achieved while the film is transported forward based on the linear velocity difference between the lateral tension wheel and the longitudinal tension wheel; by using the synergistic effect of the binding rope with the lateral tension wheel and the longitudinal tension wheel, the lateral and longitudinal tensile forces are applied respectively to a different tangent plane of the film surface, thereby forming a saddle-shaped surface.

As shown in Fig. 1 or 2, the herringbone wheel unit comprises two lateral sub-units arranged symmetrically, each of which is provided with one lateral tension wheel 1, with the two symmetrically arranged lateral tension wheels forming a herringbone; the lateral tension wheel is provided at the bottom with a first binding assembly, and outside with a first support plate 2 in parallel, and the

axle of the lateral tension wheel passes through the first support plate, which is provided vertically at the bottom with an underplate 3; the underplate is provided at the end close to the inlet of the herringbone wheel unit with a fork positioning column 4, and at the end near the outlet of the herringbone wheel unit with a first outlet positioning column 5, with a fork 6 arranged at the fork positioning column; the respective forks are connected at the end to a first lead screw 8 through a corresponding inlet nut 7, and the respective first outlet positioning columns are connected to a second lead screw 10 through a corresponding first outlet nut 9. The first binding assembly comprises a first binding rope 11, a first sliding wheel 12 and a first preloaded wheel 13, the first binding rope being wound on four first sliding wheels and provided outside with the first preloaded wheel; and the axle of the respective first sliding wheels passes through the first support plate. The fork is provided with a U-shaped groove, and the underplate is slid in the U-shaped groove through the fork positioning column. With respect to the centerline of the film 23, the left and right threads on the first lead screw rotate in the opposite direction, so do the left and right threads on the second lead screw. In the herringbone wheel unit, the angle formed by the ends of the two forks can be adjusted through the first lead screw, while the distance between the lateral tension wheels at the inlet is adapted to the width L_1 of the film at the inlet, and the distance between the lateral tension wheels at the outlet of the herringbone wheel unit can be adjusted through the second lead screw, thereby regulating the outlet width L_2 of the film as it is peeled from the herringbone wheel unit to achieve the stepless adjustability of the lateral tension ratio; the angle β between the two lateral tension wheels is generally in the

range $0^{\circ} < \beta < 180^{\circ}$. The edges of both sides of the preheated film are pressed by the first binding rope on the circumferential surface of two synchronously rotating lateral tension wheels, and the film is tightly and uniformly bound without gaps, so that the film is subjected uniformly to a tensile force in the lateral expansion process, the thickness of the stretched film product is more uniform, and the dimensional stability of the product is improved.

The parallel wheel unit comprises two longitudinal sub-units arranged symmetrically, each of which is provided with one longitudinal tension wheel 14, with the two symmetrically arranged longitudinal tension wheels arranged in parallel; the longitudinal tension wheel is provided at the bottom with a second binding assembly, and outside with a second support plate 15 in parallel, with the axle of the longitudinal tension wheel passing through the second support plate; the second support plate is provided at the end near the inlet of the parallel wheel unit with a guide hole, and at the end near the outlet of the parallel wheel unit with a second outlet positioning column 16; the respective guide holes are connected with a guide rod 17, and the respective second outlet positioning columns are connected to a third lead screw 19 through a corresponding second outlet nut 18. The second binding assembly comprises a second binding rope 20, a second sliding wheel 21 and a second preloaded wheel 22, the second binding rope being wound on four second sliding wheels and provided outside with the second preloaded wheel; the axle of the respective second pulleys passes through the second support plate. With respect to the centerline of the film, the left and right threads on the third lead screw rotate in the opposite direction. In the parallel wheel unit, the distance

between the parallel wheels can be adjusted through the cooperation between the third lead screw and the guide rod; generally, the distance between the two longitudinal tension wheels is slightly larger than the distance between the two lateral tension wheels at the outlet of the herringbone wheel unit; in the second binding assembly, first the tensiety of the second binding rope on the second sliding wheel is adjusted by the second preloaded wheel, and then the tightness of the film on the sliding wheel is controlled by adjusting the tensiety of the second binding rope to ensure that the film is tied tight. The parallel wheel unit has a binding assembly similar to the herringbone wheel unit and an independent preloaded structure of the binding assembly, except that the second support plate in the parallel wheel unit is fixed to the guide rod and the third lead screw, the synchronous relative movement of the parallel wheels is achieved by rotating the third lead screw, the two wheels keep parallel, the distance L_3 between the parallel wheels is slightly larger than the peeling distance L_2 of the film at the outlet of the herringbone wheel unit, the film goes into the parallel wheel unit after being stretched by the herringbone wheel unit, the film is flattened under the compression effect of the second binding rope, and the ratio of the linear velocity of the longitudinal tension wheel to the lateral tension wheel is adjusted to achieve the longitudinal stepless tension of the film.

The principle of the film stepless biaxial tension device based on saddle-shaped surface transition is as follows: In the film surface biaxial stretching process, with the lateral and longitudinal tensile forces acting respectively on a different tangent plane, the film is subjected to smooth transition in a

three-dimensional space from a narrow plane via a saddle-shaped surface to a wide plane (as shown in Fig. 3), with the thickness uniformity of the biaxial tension film regulated by controlling the shape of the saddle-shaped surface. The left and right edges of the film are bound by a binding rope to the circumferential surface of the lateral tension wheel and the longitudinal tension wheel, the lateral tension of the film being controlled by adjusting the angle between the two lateral tension wheels, the longitudinal tension of the film being controlled by adjusting the linear velocity difference between the lateral tension wheel and the longitudinal tension wheel; meanwhile the parallel wheel unit can pull the film to both sides in the width direction and flatten and shape it, and only the edge of the film contacts the device in the longitudinal stretching process, with the film surface having no friction damage.

The present invention can be well implemented as described above. The examples as described above are only the preferred examples of the present invention, and are not intended for limiting the scope of the present invention; that is, variations and modifications consistent with the present invention are intended for being encompassed by the scope of the present invention as claimed by the appended claims.

What is claimed is:

1. A film stepless biaxial tension method based on saddle-shaped surface transition, characterized in that: in a film surface biaxial stretching process, lateral and longitudinal tensile forces are applied respectively to a different tangent plane to make the film subjected to smooth transition in a three-dimensional space from a narrow plane via a saddle-shaped surface to a wide plane, with the thickness uniformity of the biaxial tension film regulated by controlling the shape of the saddle-shaped surface.

2. A film stepless biaxial tension device based on saddle-shaped surface transition for implementing the method according to claim 1, characterized in that: the device comprises a herringbone wheel unit and a parallel wheel unit, the angle between the two lateral tension wheels in the herringbone wheel unit being adjustable, the two longitudinal tension wheels in the parallel wheel unit being arranged in parallel; a binding rope is used to bind the left and right edges of the film to a circumferential surface of the lateral tension wheel and the longitudinal tension wheel; the lateral tension of the film is achieved by the rotation of the lateral tension wheel, and there is a linear velocity difference between the lateral tension wheel and the longitudinal tension wheel; the lateral tensile forces of the parallel wheel unit and longitudinal tensile forces of the herringbone wheel unit are applied respectively to a different tangent

plane; the herringbone wheel unit includes lateral sub-units which comprises one lateral tension wheel, a first support plate provided outside the lateral tension wheel, an underplate provided vertically at the bottom of the first support plate, a fork positioning column and a fork; the fork cooperates with the screw to realize the stepless biaxial tension of the film.

3. The film stepless biaxial tension device based on saddle-shaped surface transition according to claim 2, characterized in that: the herringbone wheel unit comprises two lateral sub-units arranged symmetrically, each of which is further provided with two symmetrically arranged lateral tension wheels forming a herringbone; the lateral tension wheel is provided at the bottom with a first binding assembly, and the axle of the lateral tension wheel passes through the first support plate; the underplate is provided at the end close to the inlet of the herringbone wheel unit with a fork positioning column, and at the end near the outlet of the herringbone wheel unit with a first outlet positioning column, with a fork arranged at the fork positioning column; the respective forks are connected at the end to a first lead screw through a corresponding inlet nut, and the respective first outlet positioning columns are connected to a second lead screw through a corresponding first outlet nut.

4. The film stepless biaxial tension device based on saddle-shaped surface transition according to claim 3, characterized in that: the first

binding assembly comprises a first binding rope, a first sliding wheel and a first preloaded wheel, the first binding rope being wound on a plurality of the first sliding wheels and provided outside with the first preloaded wheel; and the axle of the respective first sliding wheels passes through the first support plate.

5. The film stepless biaxial tension device based on saddle-shaped surface transition according to claim 2, characterized in that: the parallel wheel unit comprises two longitudinal sub-units arranged symmetrically, each of which is provided with one longitudinal tension wheel, with the two symmetrically arranged longitudinal tension wheels arranged in parallel; the longitudinal tension wheel is provided at the bottom with a second binding assembly, and outside with a second support plate in parallel, with the axle of the longitudinal tension wheel passing through the second support plate; the second support plate is provided at the end near the inlet of the parallel wheel unit with a guide hole, and at the end near the outlet of the parallel wheel unit with a second outlet positioning column; the respective guide holes are connected with a guide rod, and the respective second outlet positioning columns are connected to a third lead screw through a corresponding second outlet nut.

6. The film stepless biaxial tension device based on saddle-shaped surface transition according to claim 5, characterized in that: the second binding assembly comprises a second binding rope, a second sliding

wheel and a second preloaded wheel, the second binding rope being wound on a plurality of the second sliding wheels and provided outside with the second preloaded wheel; and the axle of the respective second sliding wheels passes through the second support plate.

7. The film stepless biaxial tension device based on saddle-shaped surface transition according to claim 2, characterized in that: in the herringbone wheel unit, the angle β between the two lateral tension wheels is in the range $0^\circ < \beta < 180^\circ$.