

PROCESSING METHOD OF THIN FILM SEALING LAYER

TECHNICAL FIELD

[0001] The present disclosure relates to the field of liquefied gas storage tanks for marine engineering equipment, particularly marine equipment such as ships, and particularly to a processing method of a thin film sealing layer of a liquefied gas storage tank for transportation equipment, especially marine equipment such as ships. The storage tank particularly includes the liquefied gas storage tank for marine equipment such as ships. Liquefied gases include, for example, liquefied natural gas, liquid nitrogen, liquid oxygen, liquid hydrogen, and liquid helium, etc.

BACKGROUND

[0002] Various components of a liquefied natural gas storage tank need to meet strict requirements in order to meet the demands of stable storage and non-leakage of liquefied natural gas. In related technologies, for storage vessels, special steel is required to separate compartments so as to ensure that no mutual leakage occurs between the compartments, and the compartments can withstand a low temperature at -160 °C to ensure the heat preservation inside hulls.

[0003] Outer walls of most of relevant transport vessels have a thickness of up to 3 feet, and inner walls are specially designed and constructed with nickel alloy steel, which can ensure a lower-temperature state of the liquefied natural gas. Once the inner walls crack, all the liquefied natural gas pours into spaces between the inner walls and the outer walls. The performance of a layer of the inner wall in direct contact with the liquefied natural gas is crucial to the transportation effect. The performance of the relevant layer in direct contact with the liquefied natural gas needs to be further improved.

[0004] In relevant processing methods, a molding module moves at a uniform speed when a blank plate is placed at a predetermined position, so that a predetermined shape is formed on the blank plate. However, due to a unique shape of a bulge region of a thin film sealing layer with good performance, the thickness of such bulge region molded at a uniform speed may be uneven throughout, resulting in poor performance.

[0005] Therefore, there is a need to provide a processing method to at least partially solve the above problems.

SUMMARY

[0006] The present disclosure aims to provide a processing method. In the method of the present disclosure, press plates may be pressed downward in a first stage of downward movement of a driving mechanism after a blank plate is placed at a predetermined position, where in this stage, only a shaping block is driven but slide components remain stationary; and in a second stage of the downward movement of the driving mechanism, the shaping block and the slide components are driven simultaneously, a shaping block driving portion and a slide component driving portion are fixed relative to each other. In an implementation, a speed of the driven shaping block may be different from that of the driven slide components, and in another implementation, even the speed of the shaping block may be not in fixed proportion to that of the slide components (for example, implemented by driving rods with involute faces or a programmed control logic), and the shaping block and the slide components with different speeds can cooperate to form a predetermined shape on the blank plate. A thin film sealing layer formed by such process has a bulge region with a uniform thickness throughout, and thus has superior performance.

[0007] It should be noted that in order to facilitate the driving mechanism to perform driving in different directions (such as driving the shaping block in a vertical direction and driving the slide components in a horizontal direction), it usually tends to actuate the shaping block driving portion and the slide component driving portion separately, and such configuration will cause that the shaping block driving portion and the slide component driving portion cannot be accurately associated, so that the performance of the thin film sealing layer formed collaboratively by the driven shaping block and the slide components is poor. However, according to the present disclosure, by allowing the shaping block driving portion and the slide component driving portion to be fixed relative to each other, both of them are accurately associated, which can improve the performance of the formed thin film sealing layer. On the other hand, corrugations, especially the bulge region, of the thin film sealing layer may be complex in shape, so if the shaping block driving portion and the slide component driving portion perform collaborative forming at a same speed, it may result in an uneven thickness and poor performance of the thin film sealing layer obtained, then, preferably, according to the present disclosure, the shaping block and the slide components are driven integrally while the unequal speeds of the drive block and the slide components are ensured, even the speeds of the two do not have a linear relation, so that the thin film sealing layer formed finally is uniform in thickness throughout and superior in performance.

[0008] According to one aspect of the present disclosure, a processing method of a thin film

sealing layer is provided, which includes forming transverse through-corrugations on a blank plate, and forming longitudinal through-corrugations and forming a bulge region after the formation of the transverse through-corrugations, wherein forming the longitudinal through-corrugations is implemented by a processing apparatus comprising a pair of slide components, a pair of material pressing components, a shaping block and a driving mechanism, wherein:

[0009] forming the longitudinal through-corrugations and forming the bulge regions comprises:

[0010] raising the material pressing components and keeping the pair of slide components away from each other;

[0011] placing a blank plate between the material pressing components and the slide components, and driving the material pressing components downward so that the blank plate is tightly pressed between the material pressing components and the slide components; and

[0012] operating a driving mechanism so that the pair of slide components are close to each other at a first predetermined speed while the shaping block moves downward at a second predetermined speed, wherein the first predetermined speed and the second predetermined speed are specifically correlated with respect to a predetermined shape of the bulge region.

[0013] In one implementation, operating the driving mechanism includes: keeping the pair of slide components close to each other at the non-uniform first predetermined speed while moving the shaping block downward at the second predetermined speed that is unequal to the first predetermined speed.

[0014] In one implementation, the driving mechanism includes a main horizontal plate and a vertical plate that are connected integrally, and a slide component driving portion includes driving rods, wherein operating the driving mechanism includes: moving the vertical plate downward, so that the driving rods are in contact with stressed portions of the slide components.

[0015] In one implementation, raising the material pressing components and operating the driving mechanism include: controlling a pressure source nitrogen gas springs disposed between the main horizontal plate of the driving mechanism and a pair of press plates for being pressed above the blank plate, such that the pair of press plates move vertically along with the main horizontal plate.

[0016] In one implementation, raising the material pressing components and operating the driving mechanism include: controlling guide connection limit rods such that top ends of the guide connection limit rods are abutted against a bottom side of the main horizontal plate when the pressure source nitrogen gas springs are at a maximum compression.

[0017] In one implementation, the processing apparatus further includes a shaping base located below the shaping block, and operating the driving mechanism includes moving the shaping base

together with the downward movement of the shaping block.

[0018] In one implementation, the method includes: moving a bulge region shaping block downward together with the downward movement of the shaping block.

[0019] In one implementation, operating the driving mechanism includes:

- 5 **[0020]** in a first stage of the downward movement of the driving mechanism, moving the driving mechanism downward at a uniform speed such that the press plates and the shaping block are driven to move downward at a uniform speed, and the slide components remain stationary; and
- [0021]** in a second stage of the downward movement of the driving mechanism, moving the shaping block downward at the second predetermined speed, and keeping the pair of slide
- 10 components close to each other at the first predetermined speed. In one implementation, operating the driving mechanism comprises: in the second stage of the downward movement of the driving mechanism, moving the vertical plate downward such that different regions of involute faces of the driving rods are in contact with the stressed portions of the slide components.

BRIEF DESCRIPTION OF THE DRAWINGS

- 15 **[0022]** FIG. 1 is a schematic diagram of a processing apparatus applicable to a manufacturing method according to some preferred implementations of the present disclosure;
- [0023]** FIG. 2 is a schematic view of a press plate, a shaping block, and other members of the processing apparatus in FIG. 1 from a look-up perspective;
- [0024]** FIG. 3 is a bottom view of a bulge region shaping block of the shaping block in FIG. 2;
- 20 **[0025]** FIGS. 4 and 5 are two side views of the bulge region shaping block in FIG. 3, respectively;
- [0026]** FIG. 6 is a schematic view of a separate driving rod in FIG. 1;
- [0027]** FIG. 7 is a schematic view of the processing apparatus in FIG. 1 in another operation state; and
- [0028]** FIG. 8 is a schematic view of the processing apparatus in FIG. 1 in yet another operation
- 25 state.
- [0029]** Reference numerals:
- [0030]** Processing apparatus 500
- [0031]** Air cylinder 501
- [0032]** Slide component 50
- 30 **[0033]** Force pin 51
- [0034]** Accommodating region 52

- [0035] Press plate 60
- [0036] Driving mechanism 70
- [0037] Main horizontal plate 71
- [0038] Vertical plate 72
- 5 [0039] Intermediate horizontal plate 73
- [0040] Pressure source nitrogen gas spring 74
- [0041] Inner tube 741
- [0042] Outer tube 742
- [0043] Guide connection limit rod 75
- 10 [0044] Limit portion 751
- [0045] Protrusion portion 76
- [0046] Driving rod 77
- [0047] First inclined face 771
- [0048] Vertical face 772
- 15 [0049] Second inclined face 773
- [0050] Connection section 78
- [0051] Shaping block 80
- [0052] Longitudinal through-corrugation shaping block 81
- [0053] Bulge region shaping block 82
- 20 [0054] Bottom surface 821
- [0055] First profile boundary line 8211
- [0056] Second profile boundary line 8212
- [0057] Extension section 822
- [0058] Position 8221 of the extension section connected with the bottom surface
- 25 [0059] Tail end 8222 of the extension section
- [0060] Shaping base 90
- [0061] Forming profile 91.

DETAILED DESCRIPTION

- [0062] The present disclosure provides a processing method of a thin film sealing layer of a
- 30 liquefied gas storage tank for transportation equipment, particularly marine equipment such as ships, where the storage tank is, for example, an LNG storage tank. The storage tank may be a

liquefied gas storage tank for marine equipment or a land-based apparatus for cryogenic frozen liquid. FIGS. 1-8 show schematic diagrams of a processing apparatus applicable to a manufacturing method according to preferred implementations of the present disclosure.

[0063] It should be noted first that directional and positional terms as mentioned in the present disclosure are only illustrative descriptions rather than limiting descriptions. The description about a position of a component should be understood as a relative position rather than an absolute position, and the description about an extension direction of a component should be understood as a relative direction rather than an absolute direction. Directional and positional terms related to the processing apparatus may be understood with reference to positions, directions, etc. of various components shown in FIGS. 1-8. For example, the terms such as “top side”, “upward”, “bottom side”, “downward” and the like for various components of the processing apparatus can be explained with reference to the placement orientation of the processing apparatus shown in FIGS. 1, 7, and 8; “upward” and “downward” directions are along a vertical direction as shown by D3; and a “transverse direction” and a “longitudinal direction” are two horizontal directions perpendicular to each other. The transverse direction is shown by D2, and the longitudinal direction is shown by D1. The vertical direction D3, the transverse direction D2, and the longitudinal direction D1 are orthogonal in space. “Longitudinal through-corrugations” of the thin film sealing layer refer to corrugations extending longitudinally and penetrating through a main body of a corrugated plate, and “transverse through-corrugations” refer to corrugations extending transversely and penetrating through the main body of the corrugated plate.

[0064] Referring to FIG. 1 first, a processing apparatus 500 includes a pair of slide components 50 arranged transversely side by side, a pair of material pressing components arranged transversely side by side, a shaping block 80 and a driving mechanism 70, where the pair of slide components 50 can be away from and close to each other transversely, and the pair of material pressing components are correspondingly located on top sides of the pair of slide components 50, so that a thin film sealing layer can be tightly pressed between the pair of slide components 50 and the pair of material pressing components. The shaping block 80 is located between the pair of slide components 50, and further includes a longitudinal through-corrugation shaping block 81 and a bulge region shaping block 82 as shown in FIG. 2. The driving mechanism 70 includes a slide component driving portion in contact with the pair of slide components 50, and a shaping block driving portion connected with the shaping block 80.

[0065] The driving mechanism 70 may include a main horizontal plate 71 and a vertical plate 72 that are connected integrally, where the vertical plate 72 extends downward from a center of the

main horizontal plate 71 in a transverse direction, and the slide component driving portion includes, for example, driving rods 77, and tops of the driving rods 77 are fixed on the main horizontal plate 71; and the shaping block 80 is fixed at a bottom end of the vertical plate 72. The pair of slide components 50 each has a force pin 51 protruding longitudinally, the force pins 51 have a smooth outer profile, and involute faces for being in contact with the force pins 51 are formed on the driving rods 77. When the driving mechanism 70 drives the shaping block 80 to move downward at a uniform speed, different regions of the involute faces of the driving rods 77 are in contact with the slide components 50, resulting in that the slide components 50 move at a variable speed as a whole.

[0066] It is understood that in the implementation shown in FIG. 1, the driving mechanism 70 is an integral member, such that the shaping block driving portion and the slide component driving portion are fixed relative to each other, and the shaping block driving portion is fixedly connected with the shaping block 80, while the slide component driving portion drives the slide components 50 in a frictional contact manner. Due to such configuration, although the shaping block driving portion and the slide component driving portion are consistent in speed and direction of movement, the shaping block 80 and the slide components 50 are different in speed and direction of movement. Under the action of the driving mechanism 70, the speed of the pair of slide components 50 approaching each other transversely is called a first predetermined speed, and the speed of the driving mechanism 70 moving downward is called a second predetermined speed.

[0067] In an implementation, press plates 60 of the processing apparatus 500 for being pressed above a blank plate may be also driven by the driving mechanism 70 in some cases, so that the press plates 60 can be raised to allow an operator to place the blank plate between the press plates 60 and the slide components 50. For example, in some implementations, a connecting mechanism is disposed between the driving mechanism 70 and the pair of press plates 60. The connecting mechanism is configured to allow the pair of press plates 60 to move vertically along with the driving mechanism, and to allow the driving mechanism 70 to move vertically relative to the pair of press plates 60 when the pair of press plates 60 are abutted against the top sides of the pair of slide components 50.

[0068] The driving mechanism 70 may include pressure source nitrogen gas springs 74 disposed between the main horizontal plate 71 and the press plates 60. The pressure source nitrogen gas springs 74 are constructed to be able to be locked when they are at a maximum tensile length so as to allow the pair of press plates 60 to move vertically together with the main horizontal plate 71. In order to ensure that there is no relative displacement in a horizontal direction between the

main horizontal plate 71 and the press plates 60 when the main horizontal plate 71 moves relative to the press plates 60, the processing apparatus 500 is further provided with intermediate horizontal plates 73 and guide connection limit rods 75. The intermediate horizontal plates 73 are connected below the main horizontal plate 71 fixedly by connection sections 78, top ends of the pressure source nitrogen gas springs 74 are fixed on the intermediate horizontal plates 73, and bottom ends of the pressure source nitrogen gas springs 74 are fixed on the pair of press plates 60. Bottom ends of the guide connection limit rods 75 are fixed on the press plates 60, the guide connection limit rods 75 penetrate through the intermediate horizontal plates 73 movably, and top ends of the guide connection limit rods 75 are provided with limit portions 751 that can be abutted against top sides of the intermediate horizontal plates 73. The limit portions 751 prevent the intermediate horizontal plates 73 from further moving upward relative to the guide connection limit rods 75. In an implementation, when the pressure source nitrogen gas springs 74 are at a minimum tensile length (i.e., a maximum compression), the limit portions 751 of the guide connection limit rods 75 are abutted against a bottom side of the main horizontal plate 71. It should be noted that the pressure source nitrogen gas springs 74 are installed in an inverted manner. In an installation state, the pressure source nitrogen gas springs 74 have their own tops facing downward and their own bottoms facing upward.

[0069] When the press plates 60 need to be raised, the driving mechanism 70 may be actuated to move upward. In a first stage of a process of upward movement of the driving mechanism 70, the main horizontal plate 71 and the intermediate horizontal plates 73 move upward relative to the press plates 60, the pressure source nitrogen gas springs 74 are stretched between the intermediate horizontal plates 73 and the press plates 60, and the guide connection limit rods 75 penetrate through the intermediate horizontal plates 73 so that the intermediate horizontal plates 73 move upward relative to the guide connection limit rods 75. When the pressure source nitrogen gas springs 74 are stretched to the maximum length while the limit portions 751 of the guide connection limit rods 75 are abutted against the top sides of the intermediate horizontal plates 73, the process of the upward movement of the driving mechanism 70 enters a second stage. In the second stage of the upward movement of the driving mechanism 70, the press plates 60 move upward along with the driving mechanism 70, and the press plates 60 move upward away from the slide components 50, so that the operator is allowed in this case to place the blank plate between the press plates 60 and the slide components 50.

[0070] After the blank plate has been placed between the press plates 60 and the slide components 50, the driving mechanism 70 may be actuated to move downward. In a first stage of the

downward movement of the driving mechanism 70, the pressure source nitrogen gas springs 74 are at a maximum tensile length, the limit portions 751 of the guide connection limit rods 75 are abutted against top surfaces of the intermediate horizontal plates 73, and the press plates 60 are actuated by the driving mechanism 70 to move downward along with the driving mechanism 70.

- 5 When the press plates 60 are abutted against top surfaces of the slide components 50, the process of the downward movement of the driving mechanism 70 enters a second stage. In the second stage, the press plates 60 do not move any more, the driving mechanism 70 moves downward relative to the press plates 60, the pressure source nitrogen gas springs 74 are compressed, and the guide connection limit rods 75 penetrate through and slide relative to the intermediate
10 horizontal plates 73. When the pressure source nitrogen gas springs 74 are at the minimum length while the limit portions 751 of the guide connection limit rods 75 are abutted against a bottom surface 821 of the main horizontal plate 71, the second stage ends.

[0071] In the second stage of the downward movement of the driving mechanism 70, the shaping block 80 and the slide components 50 move under the action of the driving mechanism 70 and
15 shape the blank plate. That is to say, the role of the first stage of the downward movement of the driving mechanism 70 is to drive the press plates 60; and the role of the second stage of the downward movement of the driving mechanism 70 is to drive the shaping block 80 and the slide components 50.

[0072] Protrusion portions 76 corresponding to the transverse through-corrugations on the blank
20 plate are disposed on bottom surfaces 821 of the press plates 60, and accommodating regions 52 are disposed at corresponding positions of the slide components 50. When the processing apparatus 500 processes the transverse through-corrugations on the blank plate, the transverse through-corrugations of the blank plate can be fixed by the protrusion portions 76 and the accommodating regions 52 to avoid the occurrence of deformation of the transverse through-
25 corrugations.

[0073] In other implementations not shown, the press plates 60 and the driving mechanism 70 may have other connection configurations. For example, they may be in a breakable connection configuration so that the driving mechanism and the press plates are not engaged in a first stage of upward movement of the main horizontal plate and engaged after entering a second stage of
30 the upward movement; and the driving mechanism and the press plates are engaged in a first stage of downward movement of the main horizontal plate and disconnected after entering a second stage of the downward movement. Alternatively, the press plates may have an independent driving mechanism, which can be actuated independently of the driving mechanism for the

shaping block and the slide components.

[0074] With continued reference to FIG. 1, the processing apparatus 500 is further provided with air cylinders 501 located at two transverse ends of the pair of slide component 50 pairwise. The air cylinders 501 are configured to pull the pair of slide components 50 apart before use of the processing apparatus 500 so as to move the pair of slide components 50 away from each other.

[0075] In some implementations, the specific involute faces of the driving rods 77 are configured such that a transverse movement speed (the first predetermined speed) of the pair of slide components 50 is associated with a downward movement speed (the second predetermined speed) of the shaping block driving portion, and the association relationship is specific to a structural morphology of the shaping block 80. For example, the shaping block 80 shown in FIGS. 2-5 corresponds to the involute face shown in FIG. 6. The involute face shown in FIG. 6 may cause the transverse movement speed (the first predetermined speed) of the pair of slide components 50 to be associated with the downward movement speed (the second predetermined speed) of the shaping block driving portion, so that the pair of slide components 50 and the shaping block driving portion work together to obtain longitudinal through-corrugations and a bulge region corresponding to the morphology of the shaping block in FIGS. 2-5. The configuration of the shaping block 80 as well as the involute faces of the driving rods 77 will be discussed below in conjunction with FIGS. 2-5 and 6 respectively.

[0076] Referring to FIG. 2, the shaping block 80 includes a longitudinal through-corrugation shaping block 81 extending longitudinally and a bulge region shaping block 82 located longitudinally at a center of the longitudinal through-corrugation shaping block 81, where the longitudinal through-corrugation shaping block 81 is configured to form the longitudinal through-corrugations of the thin film sealing layer on the blank plate, and the bulge region shaping block 82 is configured to form a bulge region where the transverse and longitudinal through-corrugations of the thin film sealing layer intersect on the blank plate. Only a transverse size of the transverse through-corrugation shaping block 81 is gradually reduced in a top-down direction; and a transverse size and a longitudinal size of the bulge region shaping block 82 are both gradually reduced in the top-down direction. That is to say, in a projection plane defined by the vertical direction and the transverse direction, a projection of the longitudinal through-corrugation shaping block 81 is formed as a downward bullet type rough cone; and in the projection plane (see FIG. 4) defined by the vertical direction and the transverse direction and a projection plane (see FIG. 5) defined by the vertical direction and the longitudinal direction, the projection of the bulge region shaping block 82 is formed as a downward bullet type rough cone. The processing

apparatus 500 is further provided with a shaping base 90 (see FIG. 1) located below the longitudinal through-corrugation shaping block 81. The shaping base 90 is located below the shaping block 80, and a top surface of the shaping base 90 has a forming profile 91 recessed downward. When the shaping block 80 moves downward, the shaping base 90 moves together.

- 5 In an implementation, a spring is disposed under the shaping base 90. When a mold is opened, the shaping base 90 moves upward under the action of an elastic force of the spring; and when the mold is closed, the shaping block 80 moves downward to push the shaping base 90 to move downward, and the spring is compressed.

[0077] FIGS. 3-5 show a particular structure of the bulge region shaping block 82 in detail. FIG. 10 3 shows a top view of the bulge region shaping block 82, and FIGS. 4 and 5 show two side views of the bulge region shaping block 82. The bulge region shaping block 82 includes a roughly smooth bottom surface 821 having four corners that are symmetric longitudinally and laterally about a center C of the bottom surface pairwise; and the bulge region shaping block 82 further includes four extension sections 822 extending upward from the four corners respectively. It 15 should be noted that the “smooth bottom surface” refers to that the bottom surface itself has no edges or corners.

[0078] Referring to FIG. 3, the bottom surface 821 has four smooth profile boundary lines successively connected between the four extension sections 822, and all of the four profile boundary lines are recessed towards the center C of the bottom surface 821 at their respective 20 intermediate positions. It can be understood that “recessed” here refers to being recessed within a roughly horizontal plane. In an implementation, among the four profile boundary lines, two profile boundary lines (the first profile boundary lines 8211) located longitudinally at both ends of the bottom surface 821 have a recessed first radius of curvature, and two profile boundary lines (the second profile boundary lines 8212) located transversely at both ends of the bottom surface 25 821 have a recessed second radius of curvature, wherein the first radius of curvature is greater than the second radius of curvature, so that the first profile boundary lines 8211 have a gentler radian than the second profile boundary lines 8212. Alternatively, the first radius of curvature may be equal to the second radius of curvature. Moreover, the second profile boundary lines 8212 have a first length, and the first profile boundary lines 8211 have a second length, wherein the 30 first length is less than the second length. It can be understood that such configuration causes a longitudinal size of the bottom surface 821 to be less than its transverse size.

[0079] The bottom surface 821 transitions to the extension sections 822 smoothly. An included angle between any position of the bottom surface 821 and a horizontal plane is less than an

included angle between an overall extension direction of the extension sections 822 and the horizontal plane. That is to say, referring to FIGS. 4 and 5, the bottom surface 821 is a roughly horizontal arced face, while the extension sections 822 extend significantly upward. The overall extension direction of each of the extension sections 822 intersects the transverse direction, the longitudinal direction, and the vertical direction. A component of the overall extension direction of the extension sections 822 within the horizontal plane is shown by D4 in FIG. 3; and a component of the overall extension direction of the extension sections 822 in the plane defined by the transverse direction and the vertical direction is shown by D6 in FIG. 4.

[0080] In a bottom view (FIG. 3) of the bulge region shaping block 82, a main body portion of each of the extension sections 822 extends along a direction that intersects both the longitudinal direction D1 and the transverse direction D2. That is, the direction D4 is neither parallel to the longitudinal direction D1 nor parallel to the transverse direction D2. A component of an extension direction of a tail end 8222 of each of the extension sections 822 away from the bottom surface 821 in this figure is D5, D5 is parallel to the transverse direction D2, and the main body portion transitions to the tail end smoothly. In an implementation, referring to FIG. 4, each of the extension sections 822 has a maximum thickness W at a position 8221 where it is connected with the bottom surface 821. In a direction from the position 8221 where each of the extension sections 822 is connected with the bottom surface 821 to the tail end 8222 away from the bottom surface 821, a thickness of the extension section 822 gradually decreases.

[0081] In an implementation, a bottommost end of a projection of the bulge region shaping block 82 within the projection plane defined by the vertical direction D3 and the transverse direction D2 is a curved face (see FIG. 4), and a bottommost end of a projection within the projection plane defined by the vertical direction D3 and the longitudinal direction D1 is a horizontal straight line segment (see FIG. 5). That is to say, from the center C of the bottom surface 821, the bottom surface 821 extends smoothly both along the transverse direction D2 and upward, but the bottom surface 821 extends along the longitudinal direction D1 without an upward component. A diversion core having a predetermined punch shape is installed on the bulge region shaping block 82, and a hardness of the diversion core is greater than that of other portions of the shaping block 80.

[0082] The involute face of the driving rod 77 corresponding to the shaping block 80 in FIGS. 2-5 is shown in FIG. 6. Referring to FIG. 6, the involute face includes a first inclined face 771, a vertical face 772, and a second inclined face 773 from top to bottom, wherein the first inclined face 771 and the second inclined face 773 form an obtuse angle with a vertical line, and the

vertical face 772 is parallel to the vertical line. The first inclined face 771 transitions to the vertical face 772 smoothly and has an extension length greater than that of the second inclined face 773. The first inclined face 771 is roughly parallel to the second inclined face 773. Moreover, a non-slip driving feature structure is disposed on the first inclined face 771, and includes, for example, a plurality of edges extending longitudinally and arranged along the vertical direction.

[0083] For example, for the shaping block 80 shown in FIGS. 2-5, the included angle of the first inclined face 771 relative to the vertical line, the extension length of the first inclined face 771, and the like may be configured particularly to cause the first predetermined speed and the second predetermined speed to be specifically correlated, so that the pair of slide components 50 approach each other at the first predetermined speed while the shaping block 80 moves downward at the second predetermined speed, thereby forming the blank plate by extrusion and obtaining the longitudinal through-corrugations and the bulge region that correspond to the shape of the shaping block 80 shown in FIGS. 2-5.

[0084] It should be noted that although the involute face in FIG. 6 corresponds to the shaping block 80 shown in FIGS. 2-5, it can be understood that in actual industrial design, the shaping block 80 corresponding to the involute face in FIG. 6 is not exactly the same as the shaping block 80 in FIGS. 2-5 necessarily, and the involute face corresponding to the shaping block 80 in FIGS. 2-5 is not exactly the same as the involute face in FIG. 6 necessarily. Inspired by the implementations shown in FIGS. 2-6, a designer can design other possible configurations of the involute face and the shaping block that have a corresponding relationship, so that the pair of slide components approach each other at the first predetermined speed while the shaping block moves downward at the second predetermined speed, and the desired longitudinal through-corrugations and bulge region are obtained.

[0085] For example, it is known from multiple experiments in the present disclosure that an involute face including a first inclined face and a first vertical face can correspond to a bulge region shaping block having a smooth bottom surface and four extension sections, and an overall extension direction of each of the extension sections intersects a transverse direction, a longitudinal direction, and a vertical direction, as long as particular arrangements for an inclination angle and a length of the inclined face as well as other detailed arrangements for the shaping block fall within a reasonable range. The involute face including the first inclined face, the first vertical face, and a second inclined face can correspond to such shaping block: a bulge region includes a bottom surface and four extension sections, the bottom surface has four smooth profile boundary lines successively connected between the four extension sections, and all of the

four profile boundary lines are recessed towards a center of the bottom surface at intermediate positions, as long as particular arrangements for inclined angles and lengths of the inclined faces as well as other detailed arrangements for the shaping block fall within a reasonable range.

[0086] In addition to the implementation shown in FIG. 6, the driving rod may have other involute faces. For example, an involute face may include a curved face recessed or protruding outward; an involute face may further include a curved face and a flat face that are disposed alternately; and an involute profile may include a plurality of curved faces with different radii of curvature. The process designer may correspondingly design the involute face of the driving rod according to the morphology of the shaping block.

[0087] In addition to the implementation shown in FIG. 1, the driving mechanism may also have other configurations to cause the first predetermined speed and the second predetermined speed to be specifically correlated with respect to a predetermined forming profile of the bulge region. For example, the driving mechanism may be connected with the slide components fixedly and/or connected with the shaping block in a manner of rolling or sliding friction; the driving mechanism itself may include a non-fixedly connected linkage mechanism, for example, the driving mechanism may include a first driving portion and a second driving portion having different movement directions and/or speeds, wherein the first driving portion may be connected with the slide components, and the second driving portion may be connected with the shaping block; and the driving mechanism may include a control module which may be programmed to drive the shaping block to move downward at the second predetermined speed while driving the slide components to approach each other at the first predetermined speed.

[0088] In some implementations, the longitudinal through-corrugations processed by the processing apparatus 500 are small corrugations, while the transverse through-corrugations are large corrugations, and the transverse through-corrugations are greater in height and width than the longitudinal through-corrugations. Correspondingly, both the width and height of the protrusion portions 76 of the press plates 60 are greater than the width and height of the longitudinal through-corrugation shaping block 81. In some implementations, cross-sectional profiles of the protrusion portions 76 of the press plates 60 are arced faces, a cross-sectional profile of the longitudinal through-corrugation shaping block 81 is also an arced face, and the corrugations processed by such device are called circular arc corrugations. In other implementations, cross-sectional profiles of the protrusion portions 76 of the press plates 60 may be roughly triangular, a cross-sectional profile of the longitudinal through-corrugation shaping block 81 may be also roughly triangular, and the corrugations processed by such device are called

triangular corrugations.

[0089] In some other implementations, it may be also possible not to provide the bulge region shaping block, as long as the involute face corresponds to the longitudinal through-corrugation shaping block. When the blank plate is formed by using the longitudinal through-corrugation shaping block, the bulge region may be formed naturally at intersections of the transverse and longitudinal corrugations of the blank plate.

[0090] FIGS. 1, 7 and 8 show different working states of the processing apparatus 500 in some preferred implementations, and the method provided by the present disclosure will be described below in conjunction with FIGS. 1, 7 and 8.

[0091] When it is necessary to use the processing apparatus 500 to produce the longitudinal through-corrugations and the bulge region on the blank plate that already has transverse through-corrugations, the driving mechanism 70 may first be actuated so that the driving mechanism 70 may be moved upward to raise the press plates 60. In an implementation, in the first stage of the upward movement of the driving mechanism 70, the pressure source nitrogen gas springs 74 are stretched, the guide connection limit rods 75 slide relative to the intermediate horizontal plates 73, the press plates 60 do not move, and the driving mechanism 70 moves upward relative to the press plates 60. In the second stage of the upward movement of the driving mechanism 70, the pressure source nitrogen gas springs 74 are at the longest tensile length, the limit portions 751 of the guide connection limit rods 75 are abutted against the top ends of the intermediate horizontal plates 73, the driving mechanism 70 drives the press plates 60 to move upward, and the press plates 60 move upward away from the slide components 50. Moreover, it is also necessary, in this case, to actuate the air cylinders 501 to move the pair of slide components 50 away from each other transversely. The state in this case is shown in FIG. 1. It can be seen from FIG. 1 that inner tubes 741 of the stretchable sleeves are exposed outside outer tubes 742.

[0092] Subsequently, the operator places the blank plate into a gap between the slide components 50 and the press plates 60 and causes the transverse through-corrugations of the blank plate to be exactly located within the accommodating regions 52 and to be pressed by the protrusion portions 76 correspondingly in shape. Subsequently, the driving mechanism 70 is actuated so that the driving mechanism 70 is moved downward. In the first stage of the downward movement of the driving mechanism 70, the pressure source nitrogen gas springs 74 are locked at the maximum elongation length, the limit portions 751 of the guide connection limit rods 75 are abutted against the top sides of the intermediate horizontal plates 73, and the press plates 60 move downward along with the driving mechanism 70, until the press plates 60 are abutted against the top sides of

the slide components 50. The state in this case is shown in FIG. 7. It can be seen from FIG. 7 that the inner tubes 741 of the stretchable sleeves are exposed outside the outer tubes 742.

[0093] Subsequently, the driving mechanism 70 continues to move downward, and this stage is the second stage of the downward movement of the driving mechanism 70. In the second stage of the downward movement of the driving mechanism 70, the pressure source nitrogen gas springs 74 are compressed, the guide connection limit rods 75 penetrate through the intermediate horizontal plates 73 so as to slide relative to the intermediate horizontal plates 73, and the driving mechanism 70 cannot actuate the press plates 60 downward. The second stage of the downward movement of the driving mechanism 70 is mainly used to actuate the shaping block 80 and the slide components 50.

[0094] In the second stage of the downward movement of the driving mechanism 70, the shaping block 80, which is installed at the bottom end of the vertical plate 72 of the driving mechanism 70 fixedly, moves downward at a second predetermined speed along with the driving mechanism 70 while the involute faces of the driving rods 77 of the driving mechanism 70 contact and push the force pins 51 of the slide components 50. The shapes of the involute faces are designed such that when the driving mechanism 70 moves downward at the second predetermined speed, the pair of slide components 50 approach each other at a non-uniform first predetermined speed. The second predetermined speed and the first predetermined speed are specifically correlated but not equal. "Specifically correlated" means that an association relationship between the second predetermined speed and the first predetermined speed is set specifically for the particular morphology of the shaping block 80. In an implementation, the first predetermined speed and the second predetermined speed do not even have a linear relation, that is, the first predetermined speed and the second predetermined speed may not increase or decrease in equal proportions. In the second stage of the downward movement of the driving mechanism 70, the shaping base 90, the shaping block 80 and the pair of slide components 50 jointly extrude the blank plate to obtain the predetermined longitudinal through-corrugations and the bulge region. Running speeds of various portions that move in different directions to extrude the blank plate are specifically associated, so that the formation process is particularly applicable to the thin film sealing layer having the predetermined corrugated shape.

[0095] The state at the end of the second stage of the downward movement of the driving mechanism 70 is shown in FIG. 8. In this case, the pair of slide components 50 are located closest relative to each other, and the shaping block 80 is pressed against between the pair of slide components 50 and pressed against a top side of the shaping base 90. In this case, the pressure

source nitrogen gas springs 74 are at a position where they are shortest, and it can be seen that the inner tubes are completely accommodated within the outer tubes 742. In this case, the limit portions 751 of the guide connection limit rods 75 are abutted against the bottom side of the main horizontal plate 71.

- 5 **[0096]** In the first stage of the downward movement of the driving mechanism 70, the driving mechanism 70 as a whole may have a uniform downward movement speed. In the second stage of the downward movement of the driving mechanism 70, due to the presence of a reaction force of the pressure source nitrogen gas springs 74, the downward movement speed of the driving mechanism 70, that is, the speed of the driven shaping block 80 (the second predetermined speed),
10 may be also a variable speed, such as a gradually decelerated variable speed; alternatively, in some other implementations, a control system that controls the driving mechanism 70 to move downward may be pre-programmed and perform the following operating logic: in the second stage, an action force on the driving mechanism 70 is gradually increased, and the increased action force may be balanced with the reaction force of the pressure source nitrogen gas springs 74, so
15 that the driving mechanism 70 continues to move downward at a constant speed in the second stage, that is to say, the speed (the second predetermined speed) of the driven shaping block 80 in this case may still be roughly uniform. Regardless of whether the downward movement speed of the shaping block 80 is uniform in the second stage, the movement speed (the first predetermined speed) of the slide components 50 is non-uniform and not equal to the second
20 predetermined speed, or even does not have a linear relation with the second predetermined speed. **[0097]** It should be noted that the “speed” as mentioned in the present disclosure should be understood as a magnitude of a velocity value of the speed, for example, “the first predetermined speed is not equal to the second predetermined speed” as mentioned in the present disclosure means that the velocity value of the transient first predetermined speed is not equal to the velocity
25 value of the transient second predetermined speed at any time node. **[0098]** Thereafter, the operator may actuate the driving mechanism 70 again to move it upward again while driving the air cylinders 501 to make the pair of slide components 50 away from each other, so that the processing apparatus 500 is restored to the state shown in FIG. 1 to facilitate the operator taking out the finished thin film sealing layer.
- 30 **[0099]** According to the method of the present disclosure, the press plates may be pressed downward in the first stage of the downward movement of the driving mechanism after the blank plate is placed at the predetermined position; and in the second stage of the downward movement of the driving mechanism, the shaping block and the slide components are driven simultaneously,

the shaping block driving portion and the slide component driving portion are fixed relative to each other; in an implementation, the speed of the driven shaping block may be also different from that of the driven slide components; in another implementation, the speed of the shaping block may be not in fixed proportion to that of the slide components (for example, implemented by the an involute profile or the programmed control logic), and the shaping block and the slide components with different speeds may cooperate to form a predetermined shape on the blank plate. A thin film sealing layer formed by such process has a bulge region with a uniform thickness throughout, and thus has superior performance.

[0100] It should be noted that in order to facilitate the driving mechanism to perform driving in different directions (such as driving the shaping block in the vertical direction and driving the slide components in the horizontal direction), it usually tends to actuate the shaping block driving portion and the slide component driving portion separately, and such configuration will cause that the shaping block driving portion and the slide component driving portion cannot be accurately associated, so that the performance of the thin film sealing layer formed collaboratively by the driven shaping block and the slide components is poor. However, according to the present disclosure, by allowing the shaping block driving portion and the slide component driving portion to be fixed relative to each other, both of them are accurately associated, which can improve the performance of the formed thin film sealing layer. On the other hand, corrugations, especially the bulge region, of the thin film sealing layer may be complex in shape, so if the shaping block driving portion and the slide component driving portion perform collaborative forming at a same speed, it may result in an uneven thickness and poor performance of the thin film sealing layer obtained, then, preferably, according to the present disclosure, the shaping block and the slide components are driven integrally while the unequal speeds of the drive block and the slide components are ensured, even the speeds of the two do not have a linear relation, so that the thin film sealing layer formed finally is uniform in thickness throughout and superior in performance.

[0101] The above implementations are used only for exemplary purposes and not for restrictive purposes. Those skilled in the art may make variations to the above implementations, and the variation results fall within the scope of protection of the present disclosure.

CLAIMS

1. A processing method of a thin film sealing layer, comprising: forming transverse through-corrugations on a blank plate, and forming longitudinal through-corrugations and forming a bulge region after the formation of the transverse through-corrugations, wherein forming the longitudinal through-corrugations is implemented by a processing apparatus comprising a pair of slide components, a pair of material pressing components, a shaping block and a driving mechanism,

wherein forming the longitudinal through-corrugations and forming the bulge regions comprises:

raising the material pressing components and keeping the pair of slide components away from each other;

placing a blank plate between the material pressing components and the slide components; and operating a driving mechanism downward, wherein:

in a first stage of downward movement of the driving mechanism, driving the material pressing components downward so that the blank plate is tightly pressed between the material pressing components and the slide components; and

in a second stage of the downward movement of the driving mechanism, keeping the pair of slide components close to each other at a first predetermined speed while moving the shaping block downward at a second predetermined speed, wherein the first predetermined speed and the second predetermined speed are specifically correlated with respect to a predetermined shape of the bulge region,

wherein the driving mechanism has a uniform downward movement speed in the first stage, and the downward movement speed of the driving mechanism is decreased gradually in the second stage, such that the second predetermined speed is decreased gradually.

2. The method of claim 1, wherein operating the driving mechanism comprises: keeping the pair of slide components close to each other at the non-uniform first predetermined speed while moving the shaping block downward at the second predetermined speed that is unequal to the first predetermined speed, wherein the first predetermined speed and the second predetermined speed has a nonlinear relation therebetween.

3. The method of claim 1 or 2, wherein the driving mechanism comprises a main horizontal plate and a vertical plate that are connected integrally, and a slide component driving portion comprises driving rods, wherein operating the driving mechanism comprises: moving the vertical plate downward, so that the driving rods are in contact with stressed portions of the slide components.

4. The method of claim 3, wherein raising the material pressing components and operating the driving mechanism comprise: controlling pressure source nitrogen gas springs disposed between the main horizontal plate of the driving mechanism and a pair of press plates for being pressed above the blank plate, such that the pair of press plates move vertically along with the main horizontal plate.

5. The method of claim 4, wherein raising the material pressing components and operating the driving mechanism comprise: controlling guide connection limit rods such that top ends of the guide connection limit rods are abutted against a bottom side of the main horizontal plate when the pressure source nitrogen gas springs are at a maximum compression.

6. The method of claim 1, wherein the processing apparatus further comprises a shaping base located below the shaping block, and operating the driving mechanism comprises moving the shaping base together with the downward movement of the shaping block.

7. The method of claim 1, comprising: moving a bulge region shaping block downward together with the downward movement of the shaping block.

8. The method of claim 4, wherein operating the driving mechanism comprises:
in the first stage of the downward movement of the driving mechanism, moving the driving mechanism downward at a uniform speed such that the pair of press plates and the shaping block are driven to move downward at a uniform speed, and the slide components remain stationary; and

in the second stage of the downward movement of the driving mechanism, moving the shaping block downward at the second predetermined speed, and keeping the pair of slide components close to each other at the first predetermined speed.

9. The method of claim 8, wherein operating the driving mechanism comprises: in the second stage of the downward movement of the driving mechanism, moving the vertical plate downward such that different regions of involute faces of the driving rods are in contact with the stressed portions of the slide components.