DESCRIPTION

TITLE OF INVENTION: COATING LAYER REMOVAL DEVICE AND COATING LAYER REMOVAL METHOD

TECHNICAL FIELD

[0001]

The present invention relates to a coating layer removal apparatus and a coating layer removal method.

BACKGROUND ART

[0002]

Recently, in order to protect global resources and environment, activities for constructing a recycling-based society through reduction, reuse, recycle, and the like of wastes are being intensified in various fields.

For instance, Patent Literature 1 discloses a recycling method of plastic products provided with a paint film, the method including peeling off the paint film formed on the plastic body from a plastic body using high-pressure jet water and fracturing and recycling the plastic body.

Patent Literature 2 discloses a coating film removal method for a resin molded article, the method including spraying, through a nozzle, high-pressure water pressurized to a range from 300 kg/cm^2 to 2,000 kg/cm^2 toward a coating film applied to the resin molded article.

Patent Literature 3 discloses a method for producing a recycled polycarbonate sheet, the method including peeling off and removing a degraded surface layer of a polycarbonate sheet by a water jet using high-pressure water having a pressure in a range from 300 kg/cm^2 to 2,000 kg/cm^2, and recycling the polycarbonate sheet, from which the degraded surface layer has been peeled off and removed, by hot-press molding.

Patent Literature 4 discloses a coating layer removal apparatus for removing a coating layer from a laminated film including a base film and the coating layer, the apparatus including an unwinding unit for unwinding the laminated film from a roll around which the laminated film is wound, a stretching unit for stretching the unwound

laminated film, a removal unit for removing the coating layer from the stretched laminated film, and a winding unit for winding the base film into a roll.

CITATION LIST

PATENT LITERATURE(S)

[0003]

Patent Literature 1: JP 5-269743 A

Patent Literature 2: JP 6-246744 A

Patent Literature 3: JP 7-080839 A

Patent Literature 4: JP 2023-148861 A

SUMMARY OF THE INVENTION

PROBLEM(S) TO BE SOLVED BY THE INVENTION

[0004]

Patent Literatures 1 to 3 each disclose a method for removing a to-be-peeled layer (paint film, coating film, or degraded surface layer) from a molded article (e.g., plastic body) using high-pressure water. However, in the methods described in Patent Literatures 1 to 3, since the to-be-peeled layer is removed from each molded article, it is difficult to continuously process a large number of molded articles.

Further, in the method described in Patent Literature 1, after the paint film is peeled off, the plastic body is fractured and recycled. In the method described in Patent Literature 3, after the degraded surface layer is removed, the polycarbonate sheet is recycled by hot-press molding. Thus, in the methods described in Patent Literatures 1 and 3, the plastic body or the polycarbonate sheet cannot be directly reused, resulting in complicated processes.

Further, since the removal apparatus described in Patent Literature 4 is configured to remove the coating layer by the removal unit after stretching the laminated film by the stretching unit, the removal apparatus needs to include the stretching unit.

[0005]

An object of the invention is to provide a coating layer removal apparatus and a coating layer removal method capable of stably processing a large amount of

laminated film.

MEANS FOR SOLVING THE PROBLEM(S)

[0006]

[1] A coating layer removal apparatus configured to remove a coating layer from a laminated film including a base film and the coating layer, the removal apparatus including: a roll unwinding shaft configured to unwind the laminated film; a first backup roller disposed downstream of the roll unwinding shaft, configured to abut the base film of the laminated film, and configured to convey the laminated film downstream; a first jet-spray unit including one or more nozzles disposed to face the first backup roller; a second jet-spray unit disposed downstream of the first jet-spray unit and including one or more nozzles disposed to face either the first backup roller or a second backup roller different from the first backup roller; a pressurized-water supply unit configured to pressurize water and supply the pressurized water to the first jet-spray unit and the second jet-spray unit; and a roll winding shaft configured to wind the base film, from which the coating layer has been removed, into a roll, in which the pressurized-water supply unit includes one or more pumps, and each of the first jet-spray unit and the second jet-spray unit is connected to at least one of the one or more pumps.

[2] The coating layer removal apparatus according to [1], in which, when viewed along a conveyance direction of the laminated film, the one or more nozzles included in the first jet-spray unit and the one or more nozzles included in the second jet-spray unit are arranged in a staggered manner such that at least some of the nozzles do not overlap each other in the conveyance direction of the laminated film.

[3] The coating layer removal apparatus according to [1] or [2], in which, when at least one of the first jet-spray unit or the second jet-spray unit includes a plurality of nozzles, the plurality of nozzles are arranged along at least one direction intersecting the conveyance direction of the laminated film.

[4] The coating layer removal apparatus according to any one of [1] to [3], in which the second jet-spray unit is disposed such that pressurized water impinges on a region of the laminated film on which the pressurized water jet-sprayed from the first jet-spray unit does not impinge.

[5] The coating layer removal apparatus according to any one of [1] to [4] further includes a water recovery and recycling apparatus configured to recover and recycle water jet-sprayed from the first jet-spray unit and the second jet-spray unit, in which the water recovery and recycling apparatus is connected to the pressurized-water supply unit.

[6] The coating layer removal apparatus according to any one of [1] to [5] further includes a residue detection apparatus configured to detect residue of the coating layer, in which the residue detection apparatus is disposed downstream of the second backup roller and upstream of the roll winding shaft.

[7] The coating layer removal apparatus according to any one of [1] to [6] further includes a residue removal apparatus configured to remove residue of the coating layer, in which the residue removal apparatus is disposed downstream of the second backup roller and upstream of the roll winding shaft.

[0007]

[8] A coating layer removal method includes: unwinding, from a roll around which a laminated film including a base film and a coating layer is wound, the laminated film; performing first jet-spraying by jet-spraying pressurized water toward a first jet-spray region of the coating layer when the unwound laminated film passes at least one backup roller, thereby fracturing the coating layer; after the first jet-spraying, performing second jet-spraying by jet-spraying pressurized water toward a second jet-spray region of the coating layer including at least a region other than the first jet-spray region when the laminated film passes the at least one backup roller, thereby fracturing the coating layer in the second jet-spray region that is not fractured by the first jet-spraying; washing away the fractured coating layer; and winding, into a roll, the base film after the coating layer is washed away.

[9] The coating layer removal method according to [8], in which the first jet-spraying is performed by jet-spraying pressurized water from a first jet-spray unit including one or more nozzles disposed to face the at least one backup roller; the second jet-spraying is performed by jet-spraying pressurized water from a second jet-spray unit including one or more nozzles disposed to face the at least one backup roller; and for each of the first jet-spraying and the second jet-spraying, a corresponding backup roller among the at least one backup roller supports the

laminated film during the corresponding jet-spraying, and, when viewed in a cross section perpendicular to a central axis of the corresponding backup roller, a jet-spraying direction of the pressurized water from the corresponding one of the first jet-spray unit and the second jet-spray unit is perpendicular to a peripheral tangent of the corresponding backup roller.

[10] The coating layer removal method according to [8] or [9], further including removing residue of the coating layer after washing away the fractured coating layer and before winding the base film into a roll.

[11] The coating layer removal method according to any one of [8] to [10], further including: recovering water used in the first jet-spraying and the second jet-spraying; and reusing at least a portion of the recovered water in the first jet-spraying and the second jet-spraying.

[0008]

According to the above aspects of the invention, a coating layer removal apparatus and a coating layer removal method capable of stably processing a large amount of laminated film can be provided.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1A schematically illustrates a coating layer removal apparatus according to a first exemplary embodiment.

Fig. 1B schematically illustrates a first jet-spray unit and a first backup roller as viewed from a downstream side to an upstream side of a conveyance path of a laminated film in the first exemplary embodiment.

Fig. 1C schematically illustrates a second jet-spray unit and a second backup roller as viewed from the downstream side to the upstream side of the conveyance path of the laminated film in the first exemplary embodiment.

Fig. 1D schematically illustrates jet-spray units and the laminated film as viewed in a direction from a proximal end of a nozzle to a nozzle tip in the first exemplary embodiment.

Fig. 2 is an example of a cross-sectional view of the laminated film usable in the coating layer removal apparatus.

Fig. 3 schematically illustrates a coating layer removal apparatus according to a second exemplary embodiment.

Fig. 4 schematically illustrates a coating layer removal apparatus according to a third exemplary embodiment.

Fig. 5 schematically illustrates jet-spray units and the laminated film as viewed in a direction from a proximal end of a nozzle to a nozzle tip in modifications of the exemplary embodiments.

DESCRIPTION OF EMBODIMENT(S)

[0010]

Herein, ordinal expressions such as “first” and “second” are used for the purpose of distinguishing components and do not indicate an order.

Herein, an expression without an ordinal, such as “jet-spray unit,” is used as a generic term for jet-spray units when describing features common to jet-spray units designated by ordinals such as “first” and “second.” For instance, when a description is commonly applicable to a plurality of components designated by ordinals, such as a “first jet-spray unit” and a “second jet-spray unit,” the expression “jet-spray unit,” from which the ordinal is omitted, is used to collectively refer to the first jet-spray unit and the second jet-spray unit.

[0011]

First Exemplary Embodiment

Coating Layer Removal Apparatus

A first exemplary embodiment of the invention will be described with reference to the attached drawings.

It should be noted that X axis, Y axis, and Z axis are orthogonal to each other, where X axis and Y axis are in a predetermined plane and Z axis is orthogonal to the predetermined plane. Further, directions in the exemplary embodiment are defined with reference to a viewpoint at a near side in Fig. 1A, Fig. 3, or Fig. 4 viewed parallel to the Y axis, where "upper" is a direction pointed by an arrow of the Z axis and "lower" is a direction reverse to the "upper" direction, "right" is a direction pointed by an arrow of the X axis and "left" is a direction reverse to the "right" direction, and "front" is a direction toward the near side in Fig. 1A, Fig. 3, or Fig. 4 parallel to the Y

axis and "back" is a direction reverse to the "front" direction.

[0012]

Fig. 1A schematically illustrates a coating layer removal apparatus 100 according to the exemplary embodiment.

The removal apparatus 100 illustrated in Fig. 1A is configured to remove a coating layer from a laminated film while continuously conveying the laminated film in a roll-to-roll process.

Fig. 2 is an example of a cross-sectional view illustrating a laminated film 90 used in the removal apparatus 100. The laminated film 90 includes a base film 91 and a coating layer 92. The base film 91 and the coating layer 92 are in direct contact with each other. The base film 91 includes a first film surface 91a and a second film surface 91b opposite the first film surface 91a. The coating layer 92 includes a first coating surface 92a and a second coating surface 92b opposite the first coating surface 92a. The coating layer 92 is laminated on the base film 91 so that the second coating surface 92b of the coating layer 92 is in contact with the second film surface 91b of the base film 91.

The laminated film 90 is not particularly limited as long as the laminated film 90 includes the base film 91 and the coating layer 92.

Details of the base film 91 and the coating layer 92 will be described later.

[0013]

The removal apparatus 100 according to the exemplary embodiment includes a roll unwinding shaft 10 configured to unwind the laminated film 90; a first backup roller 21 disposed downstream of the roll unwinding shaft 10, abutting the base film 91 of the laminated film 90, and configured to convey the laminated film 90 downstream; a first jet-spray unit 31 including one or more nozzles disposed to face the first backup roller 21; a second jet-spray unit 32 disposed downstream of the first jet-spray unit 31 and including one or more nozzles disposed to face a second backup roller 22 different from the first backup roller 21; a pressurized-water supply unit 50 configured to pressurize water and supply pressurized water W3 to the first jet-spray unit 31 and the second jet-spray unit 32; and a roll winding shaft 40 configured to wind the base film 91, from which the coating layer 92 has been removed, into a roll. The pressurized-water supply unit 50 includes a first supply pump 51 connected to

the first jet-spray unit 31 and a second supply pump 52 connected to the second jet-spray unit 32.

The removal apparatus 100 also includes a water recovery and recycling apparatus 60, a residue detection apparatus 80, a residue removal apparatus 70, a plurality of guide rollers GR, and a plurality of tension control rollers TR.

[0014]

In the removal apparatus 100 according to the exemplary embodiment, the first jet-spray unit 31 and the second jet-spray unit 32 are disposed to face the first backup roller 21 and the second backup roller 22, respectively, and, when the laminated film 90 passes the two backup rollers 21, 22, the pressurized water W3 is sequentially jet-sprayed toward the coating layer 92 from the first jet-spray unit 31 and the second jet-spray unit 32.

The jet-spraying of the pressurized water W3 from the jet-spray units 31, 32 applies impact stress (compressive stress) greater than the breaking strength of the coating layer 92 to the surface of the coating layer 92, thereby fracturing the coating layer 92. In the example illustrated in Fig. 1A, after the fractured coating layer 92 is washed away by water flows from the first jet-spray unit 31 and the second jet-spray unit 32 and residue is removed by the residue removal apparatus 70, only the base film 91 is wound onto the roll winding shaft 40 and recovered.

According to the removal apparatus of the exemplary embodiment, the coating layer can be continuously removed from the laminated film by a roll-to-roll process. As a result, a large amount of the laminated film can be processed.

Further, according to the removal apparatus of the exemplary embodiment, the coating layer can be removed substantially using only water without using chemicals, and therefore the laminated film can be stably processed. Further, according to the removal apparatus of the exemplary embodiment, since substantially only water is used, it is not necessary to treat waste liquid containing chemicals, thereby reducing waste liquid treatment costs and further reducing the impact on the global environment.

Further, according to the removal apparatus of the exemplary embodiment, the two jet-spray units 31, 32 are provided, and each of the jet-spray units 31, 32 includes one or more nozzles, thereby allowing the nozzles to be densely arranged.

As a result, the ability to remove the coating layer 92 can be enhanced.

[0015]

Each component of the removal apparatus 100 according to the exemplary embodiment will be described.

[0016]

Roll Unwinding Shaft 10

The roll unwinding shaft 10 unwinds the laminated film 90 in a roll form. The roll unwinding shaft 10 is connected to a drive roller (not illustrated).

[0017]

First Backup Roller 21 and Second Backup Roller 22

The first backup roller 21 is disposed downstream of the roll unwinding shaft 10 and upstream of the roll winding shaft 40. The second backup roller 22 is disposed downstream of the first backup roller 21 and upstream of the roll winding shaft 40.

The backup rollers 21, 22 are each disposed to abut a surface (first film surface 91a) of the base film 91 opposite the coating layer 92.

By passing the laminated film 90 over the backup rollers 21, 22, deflection of the laminated film 90 in the vertical direction (the +Z-axis direction in the case of Fig. 1A) caused by the impact of the pressurized water W3 can be eliminated, and the in-plane tension of the laminated film 90 can be made uniform, thereby maximizing the effect of the impact force of the pressurized water W3.

Further, in the example illustrated in Fig. 1A, tension control rollers TR for firmly pressing the laminated film 90 against the first backup roller 21 are disposed upstream and downstream of the first jet-spray unit 31, respectively. Similarly, tension control rollers TR are disposed upstream and downstream of the second jet-spray unit 32.

By disposing the tension control rollers TR, it is considered that deflection of the laminated film 90 in the vertical direction is further reduced and the in-plane tension becomes more uniform.

[0018]

First Jet-Spray Unit 31 and Second Jet-Spray Unit 32

The first jet-spray unit 31 includes one or more nozzles disposed to face the first backup roller 21. The second jet-spray unit 32 includes one or more nozzles

disposed to face the second backup roller 22. The second jet-spray unit 32 is disposed downstream of the first jet-spray unit 31.

In the exemplary embodiment, when viewed in a cross section perpendicular to the central axis 21a of the first backup roller 21, the central axis of each nozzle included in the first jet-spray unit 31 is perpendicular to a peripheral tangent PT1 of the first backup roller 21.

Accordingly, the central axis of each nozzle included in the first jet-spray unit 31 is disposed so as to be directed toward the central axis 21a of the first backup roller 21. For instance, Fig. 1B illustrates a central axis C1 of a nozzle 31a among the nozzles included in the first jet-spray unit 31.

Similarly, when viewed in a cross section perpendicular to the central axis 22a of the second backup roller 22, the central axis of each nozzle included in the second jet-spray unit 32 is perpendicular to a peripheral tangent PT2 of the second backup roller 22. Accordingly, the central axis of each nozzle included in the second jet-spray unit 32 is disposed so as to be directed toward the central axis 22a of the second backup roller 22. For instance, Fig. 1C illustrates a central axis C2 of a nozzle 32a among the nozzles included in the second jet-spray unit 32.

By arranging the nozzles included in the jet-spray units 31, 32 as described above, the pressurized water W3 impinges perpendicularly on the coating layer 92. Accordingly, greater impact stress is applied to the surface of the coating layer 92 at the point of impact with the coating layer 92, whereby the coating layer 92 is more readily fractured.

[0019]

In the exemplary embodiment, the jet-spray units 31, 32 are disposed in respective jet-spray chambers 301, 302, and the jet-sprayed water is directed to the second tank 63 of the water recovery and recycling apparatus 60 through respective discharge outlets 1a, 2a.

[0020]

In the exemplary embodiment, when at least one of the first jet-spray unit 31 or the second jet-spray unit 32 includes a plurality of nozzles, the plurality of nozzles are preferably arranged along at least one direction intersecting the conveyance direction of the laminated film 90.

In the exemplary embodiment, when viewed from the proximal end side of the nozzles toward the nozzle tips (jet outlets), it is preferable that the spread widths of the pressurized water jet-sprayed from the one or more nozzles included in the first jet-spray unit 31 and the one or more nozzles included in the second jet-spray unit 32 do not overlap each other, at least in part, between the nozzles within each jet-spray unit. Accordingly, the pressurized water jet-sprayed from each nozzle is prevented from spreading and interfering with the jet-spray region of an adjacent nozzle, thereby preventing the forces of the pressurized water jets from canceling each other out before the pressurized water reaches the laminated film. As a result, the entire coating layer 92 is more readily fractured.

In the exemplary embodiment, when viewed in a direction along the conveyance direction of the laminated film 90 (for example, when viewed from the downstream side to the upstream side of the conveyance path of the laminated film 90), the one or more nozzles included in the first jet-spray unit 31 and the one or more nozzles included in the second jet-spray unit 32 are preferably arranged such that at least some of the nozzles do not overlap each other, and more preferably arranged such that none of the nozzles overlap each other.

Further, in the exemplary embodiment, when viewed in the conveyance direction of the laminated film 90, the one or more nozzles included in the first jet-spray unit 31 and the one or more nozzles included in the second jet-spray unit 32 are still more preferably arranged in a staggered manner such that at least some of the nozzles do not overlap each other in the conveyance direction of the laminated film 90.

By arranging the nozzles in a staggered manner, the regions defined by the spread widths of the pressurized water jet-sprayed from the respective nozzles are offset from each other, whereby the entire coating layer 92 is more readily fractured.

In the exemplary embodiment, the second jet-spray unit 32 is preferably disposed such that the pressurized water impinges on a region of the laminated film 90 on which the pressurized water jet-sprayed from the first jet-spray unit 31 does not impinge.

[0021]

An example of the arrangement of the nozzles of the jet-spray units 31, 32

will be described with reference to Figs. 1B, 1C, and 1D. Fig. 1B schematically illustrates the first jet-spray unit 31 and the first backup roller 21 as viewed from the downstream side to the upstream side of the conveyance path of the laminated film. Fig. 1C schematically illustrates the second jet-spray unit 32 and the second backup roller 22 as viewed from the downstream side to the upstream side of the conveyance path of the laminated film in the first exemplary embodiment. Fig. 1D schematically illustrates jet-spray units 31 and 32 and the laminated film 90 as viewed in the direction from the proximal end of the nozzle to the nozzle tip.

In the first jet-spray unit 31, five nozzles 31a, 31b, 31c, 31d, and 31e are arranged at equal intervals along the Y-axis direction (Figs. 1B and 1D). In the second jet-spray unit 32, four nozzles 32a, 32b, 32c, and 32d are arranged at equal intervals along the Y-axis direction (Figs. 1C and 1D). The nozzles need not be arranged at equal intervals.

[0022]

As illustrated in Fig. 1D, arranging the nozzles in a staggered manner with the nozzles offset from one another in the X-axis direction and the Y-axis direction may be referred to as a staggered arrangement.

By arranging the nozzles in a staggered arrangement, even when a region R1 of the laminated film 90 on which the pressurized water W3 jet-sprayed from the first jet-spray unit 31 does not impinge is present, the pressurized water W3 jet-sprayed from the subsequent second jet-spray unit 32 impinges on a region including the region R1. Accordingly, the entire coating layer 92 is readily fractured. In Fig. 1D, a region R2 indicates a region in which the coating layer 92 has been fractured.

[0023]

In the exemplary embodiment, the distance from a jet outlet (nozzle tip) of each nozzle disposed in the jet-spray units 31, 32 to the backup rollers 21, 22 (indicated by D1 in Figs. 1B and 1C) is preferably in a range from 10 mm to 300 mm, more preferably in a range from 30 mm to 300 mm, and still more preferably in a range from 40 mm to 150 mm.

In the exemplary embodiment, when the distance from the jet outlet (nozzle tip) of each nozzle disposed in the jet-spray units 31, 32 to the backup rollers 21, 22 is 300 mm, the spread width of the pressurized water is, for example, in a range from

50 mm to 700 mm.

The spread width of the pressurized water means a dimension, in the width direction of the backup roller, of the pressurized water jet-sprayed from the jet outlet of the nozzle when the pressurized water reaches the surface of the laminated film.

[0024]

In the exemplary embodiment, the distance between the central axes of the nozzles within the same jet-spray unit (indicated by P2 in Fig. 1D) is preferably in a range from 20 mm to 250 mm, more preferably in a range from 30 mm to 200 mm.

An inner diameter of the jet outlet of each of the nozzles is preferably in a range from 0.2 mm to 30 mm, more preferably 0.3 mm to 10 mm.

The shape of the nozzle is not particularly limited, but the nozzle is preferably a contraction nozzle. The contraction nozzle refers to a nozzle, such as an orifice or a flow nozzle, that ejects water from a constricted jet outlet. When the nozzle is a contraction nozzle, the inner diameter of the jet outlet of the nozzle is the inner diameter of the constricted portion.

Examples of a nozzle pattern, which are not specifically limited, include a flat pattern (jet-sprayed through the jet outlet in a form of a fan), a full cone pattern (jet-sprayed through the jet outlet in a conical form), and a straight pattern (linearly jet-sprayed through the jet outlet).

Among the above, it is preferable that the nozzle pattern is the flat pattern. When the coating layer is removed from the laminated film by a roll-to-roll process as in the exemplary embodiment, when a flat pattern is used, the coating layer can be fractured with fewer nozzles than when a straight pattern is used. Further, when a flat pattern is used, the coating layer can be fractured with a smaller amount of water than when a full cone pattern is used.

[0025]

In the exemplary embodiment, when the jet-spray units 31, 32 each include a plurality of nozzles along a direction (the Y-axis direction) intersecting the conveyance direction of the laminated film 90, the number of nozzles included in each of the jet-spray units 31, 32 is preferably 0.4 or more per 100 mm of the width of the laminated film, and more preferably in a range from 0.5 to 2.5 per 100 mm of the width of the laminated film. The number of nozzles included in the respective jet-

spray units may be the same as or different from each other.

In the exemplary embodiment, when viewed from the proximal end side of the nozzles toward the nozzle tips (jet outlets), the treatment surface of the laminated film 90 is preferably located within a range extending from the central axes of the nozzles disposed at both ends in the width direction of the laminated film 90 to the outer edges of the nozzles (that is, the width of the laminated film 90 preferably falls within the range).

In the case of Fig. 1D, among all the nozzles included in the jet-spray units 31, 32, the nozzles disposed at both ends in the width direction of the laminated film 90 are the nozzle 31a and the nozzle 31e.

In Fig. 1D, the laminated film 90 fits within a range from the central axis C1 of the nozzle 31a to an outer edge L1 of the nozzle 31a and a range from the central axis C11 of the nozzle 31e to an outer edge L2 of the nozzle 31e.

Further, in the case of Fig. 5 described later, among all the nozzles included in the jet-spray unit, the nozzles disposed at both ends in the width direction of the laminated film 90 are the nozzle 35a and the nozzle 35b.

In Fig. 5, the laminated film 90 fits within a range from the central axis C5 of the nozzle 35a to an outer edge L3 of the nozzle 35a and a range from the central axis C51 of the nozzle 35b to an outer edge L4 of the nozzle 35b.

[0026]

Pressurized-Water Supply Unit 50

The pressurized-water supply unit 50 is, for example, a known pressurized-water generating apparatus.

As the water to be pressurized by the pressurized-water supply unit 50, the “water used for the pressurized water” described in the fourth exemplary embodiment can be used. The same applies to the second exemplary embodiment and the third exemplary embodiment.

The pressurized-water supply unit 50 includes a water supply source 55, a first tank 53 that stores water W1 supplied from the water supply source 55, a pipe 54 connecting the water supply source 55 and the first tank 53, and two supply pumps 51, 52. The supply pump 51 is connected to the tanks 53, 63 through pipes 531, 631, respectively, and is connected to the first jet-spray unit 31 through a pipe 511. The

supply pump 52 is connected to the tanks 53, 63 through pipes 532, 632, respectively, and is connected to the second jet-spray unit 32 through a pipe 521. The second tank 63 stores water that has been used and recycled (also referred to as recycled water W2).

In the pressurized-water supply unit 50, the water W1 stored in the first tank 53 and the recycled water W2 stored in the second tank 63 are used to generate the pressurized water.

The pressurized-water supply unit 50 pressurizes the water W1 and the recycled water W2 and supplies pressurized water W3 to the jet-spray units 31, 32 through the two supply pumps 51, 52, respectively.

[0027]

Water Recovery and Recycling Apparatus 60

In the exemplary embodiment, the water recovery and recycling apparatus 60 separates the water jet-sprayed from the first jet-spray unit 31 and the second jet-spray unit 32 from the fractured coating layer by passing the water through filters 601, 602.

The water recovery and recycling apparatus 60 includes a second tank 63 that stores the separated water as recycled water W2; a first filter 601 and a first recovery pump 61 disposed between the second tank 63 and the first jet-spray chamber 301; and a second filter 602 and a second recovery pump 62 disposed between the second tank 63 and the second jet-spray chamber 302.

The second tank 63 is connected to the two supply pumps 51, 52 of the pressurized-water supply unit 50 through pipes 631, 632.

[0028]

Residue Removal Apparatus 70

The residue removal apparatus 70 is an apparatus that removes residue of the coating layer 92, and is disposed downstream of the second backup roller 22 and upstream of the roll winding shaft 40.

Examples of the residue of the coating layer 92 include the coating layer 92 remaining on the base film 91 in a fractured state, and water and foreign matter adhering to the laminated film 90.

The residue removal apparatus 70 is not particularly limited, and examples

thereof include a blow-off nozzle (also referred to as an air knife) and a dryer. It is only necessary for the residue removal apparatus 70 to be provided at least on the side of the fractured coating layer 92.

In Fig. 1A, the residue removal apparatus 70 is a pair of blow-off nozzles.

[0029]

Residue Detection Apparatus 80

The residue detection apparatus 80 is an apparatus that detects residue of the coating layer 92, and is disposed downstream of the second backup roller 22 and upstream of the roll winding shaft 40. The residue detection apparatus 80 is, for example, a thickness gauge that measures the thickness of the coating layer 92.

The residue detection apparatus 80 may have not only a function of detecting residue of the coating layer 92 but also a function of detecting foreign matter.

[0030]

Nip Rollers NR1, NR2

In the exemplary embodiment, a pair of nip rollers NR1, NR2 are provided between the residue removal apparatus 70 and the residue detection apparatus 80.

[0031]

Roll Winding Shaft 40

The roll winding shaft 40 winds the base film 91, from which the coating layer 92 has been removed, into a roll. The roll winding shaft 40 is connected to a drive roller (not illustrated).

[0032]

Second Exemplary Embodiment

Coating Layer Removal Apparatus

A coating layer removal apparatus 100A according to a second exemplary embodiment will be described below.

The second exemplary embodiment will be described below, where difference(s) from the first exemplary embodiment will be focused and the same or similar components and features will be, for instance, denoted by the same reference numerals, thereby omitting or simplifying the description thereof.

Fig. 3 schematically illustrates a coating layer removal apparatus 100A according to the second exemplary embodiment.

The removal apparatus 100A according to the second exemplary embodiment is the same as the removal apparatus 100 described in the first exemplary embodiment, except that both the first jet-spray unit 31 and the second jet-spray unit 32 are disposed to face the first backup roller 21. Accordingly, the removal apparatus 100A does not include the second backup roller 22, the second filter 602, the second recovery pump 62, and the like.

[0033]

First Jet-Spray Chamber 301A

In the first jet-spray chamber 301A of the second exemplary embodiment, the first jet-spray unit 31, the second jet-spray unit 32, the first backup roller 21, and two tension control rollers TR are disposed. The two tension control rollers TR are disposed upstream of the first jet-spray unit 31 and downstream of the second jet-spray unit 32, respectively. In the first jet-spray chamber 301A, the first jet-spray unit 31 and the second jet-spray unit 32 are disposed above the first backup roller 21 (in the +Z-axis direction) and are each disposed to face the first backup roller 21.

In the second exemplary embodiment, when viewed in a cross section perpendicular to the central axis 21a of the first backup roller 21, the central axis of a nozzle included in the first jet-spray unit 31 (for example, the central axis C1 of the nozzle 31a in Fig. 1B) is perpendicular to a peripheral tangent PT1 of the first backup roller 21, and the central axis of a nozzle included in the second jet-spray unit 32 (for example, the central axis C2 of the nozzle 32a in Fig. 1C) is perpendicular to a peripheral tangent PT2 of the first backup roller 21. In the third exemplary embodiment, the relationships between the central axes of the nozzles included in the jet-spray units 31, 32 and the peripheral tangents PT1, PT2 of the backup roller 21 are respectively the same as the relationships between the central axes of the nozzles and the peripheral tangents PT1, PT2 in the second exemplary embodiment.

[0034]

In the second exemplary embodiment, the nozzles of the first jet-spray unit 31 and the second jet-spray unit 32 may be arranged, for example, in the nozzle arrangement (staggered arrangement) illustrated in Fig. 1D.

When different jet-spray units are disposed to face the same backup roller as in the second exemplary embodiment, a "distance between adjacent ones of the

nozzles in the Y-axis direction" disposed in adjacent jet-spray units (the first jet-spray unit 31 and the second jet-spray unit 32 in the case of Fig. 1D) is preferably in a range from 10 mm to 125 mm, more preferably in a range from 15 mm to 100 mm. The "distance between adjacent ones of the nozzles in the Y-axis direction" refers to the distance between two loci traced by the intersections of the central axes of the nozzles with the surface of the laminated film. In the case of Fig. 1D, the distance between the two loci is indicated by a distance P1 between Y coordinates.

[0035]

Water Recovery and Recycling Apparatus 60A

In the second exemplary embodiment, the water recovery and recycling apparatus 60A discharges the water jet-sprayed from the first jet-spray unit 31 and the second jet-spray unit 32 through the discharge outlet 1a and recycles the water by passing the water through the first filter 601. The water recovery and recycling apparatus 60A includes a second tank 63 that stores the recycled water W2, the first filter 601, and the first recovery pump 61.

[0036]

According to the removal apparatus 100A of the second exemplary embodiment, the same effects as those of the first exemplary embodiment can be achieved. Further, in the removal apparatus 100A according to the second exemplary embodiment, both the first jet-spray unit 31 and the second jet-spray unit 32 are disposed to face the first backup roller 21, whereby space saving can be achieved.

[0037]

Third Exemplary Embodiment

Coating Layer Removal Apparatus

A coating layer removal apparatus 100B according to a third exemplary embodiment will be described.

In the third exemplary embodiment, differences from the first exemplary embodiment and the second exemplary embodiment will be mainly described, and descriptions of similar matters will be omitted or simplified by, for example, assigning the same reference signs thereto.

Fig. 4 schematically illustrates the coating layer removal apparatus 100B according to the third exemplary embodiment.

The removal apparatus 100B according to the third exemplary embodiment differs from the removal apparatus 100A described in the second exemplary embodiment in the positions of the first jet-spray unit 31 and the second jet-spray unit 32. The other configurations are the same as those of the second exemplary embodiment.

[0038]

First Jet-Spray Chamber 301B

In a first jet-spray chamber 301B of the third exemplary embodiment, the first jet-spray unit 31, the second jet-spray unit 32, the first backup roller 21, and two tension control rollers TR are disposed. The two tension control rollers TR are disposed upstream of the first jet-spray unit 31 and downstream of the second jet-spray unit 32, respectively. In the first jet-spray chamber 301B, the first jet-spray unit 31 and the second jet-spray unit 32 are disposed below the first backup roller 21 (in the −Z-axis direction) and are each disposed to face the first backup roller 21.

[0039]

In the third exemplary embodiment, the nozzles of the first jet-spray unit 31 and the second jet-spray unit 32 may be arranged, for example, in the nozzle arrangement (staggered arrangement) illustrated in Fig. 1D.

[0040]

According to the removal apparatus 100B of the third exemplary embodiment, the same effects as those of the first exemplary embodiment can be achieved. Further, in the removal apparatus 100B according to the third exemplary embodiment, the pressurized water W3 is jet-sprayed toward the coating layer 92 from the jet-spray units 31, 32 disposed below the first backup roller 21 (in the −Z-axis direction), whereby the fractured coating layer 92 readily falls off together with the pressurized water W3. As a result, residue of the coating layer 92 can be prevented from reaching the residue removal apparatus 70 while remaining attached to the laminated film 90. Further, since the fractured coating layer 92 readily falls off when the laminated film 90 passes the jet-spray units 31, 32, the base film 91 can also be recovered without using the residue removal apparatus 70. Alternatively, the residue removal apparatus 70 may be replaced with one having a simpler mechanism.

[0041]

Fourth Exemplary Embodiment

Coating Layer Removal Method

A coating layer removal method according to a fourth exemplary embodiment includes: a step of unwinding a laminated film including a base film and a coating layer from a roll around which the laminated film is wound; a first jet-spraying step of, when the unwound laminated film passes at least one backup roller, jet-spraying pressurized water toward a first jet-spray region of the coating layer to fracture the coating layer; a second jet-spraying step of, after the first jet-spraying step, when the laminated film passes the at least one backup roller, jet-spraying pressurized water toward a second jet-spray region of the coating layer that includes at least a region other than the first jet-spray region to fracture the coating layer in the second jet-spray region that has not been fractured in the first jet-spraying step; a step of washing away the fractured coating layer; and a step of winding the base film, after the coating layer has been washed away, into a roll.

[0042]

The removal method according to the fourth exemplary embodiment can be carried out, for example, using any of the removal apparatuses according to the first exemplary embodiment to the third exemplary embodiment.

In the following description, a case where the removal method according to the fourth exemplary embodiment is carried out using the removal apparatus 100 according to the first exemplary embodiment (Fig. 1A) will be described.

[0043]

In the removal method according to the fourth exemplary embodiment, when the laminated film 90 passes the first backup roller 21 and the second backup roller 22, the pressurized water W3 is jet-sprayed onto the coating layer 92 sequentially from the first jet-spray unit 31 and the second jet-spray unit 32.

Therefore, according to the removal method of the fourth exemplary embodiment, a large amount of the laminated film can be continuously processed by a roll-to-roll process, as in the first exemplary embodiment. Further, according to the removal method of the exemplary embodiment, the coating layer can be removed using substantially only water without using chemicals, and thus the laminated film can be stably processed. Further, according to the removal method of the exemplary

embodiment, since substantially only water is used, it is not necessary to treat waste liquid containing chemicals, thereby reducing waste liquid treatment costs and further reducing the impact on the global environment.

[0044]

Water to Be Used as Pressurized Water

In the fourth exemplary embodiment, the pressurized water is used, for example, in the first jet-spraying step and the second jet-spraying step to be jet-sprayed toward the first jet-spray region and the second jet-spray region of the coating layer and to fracture the coating layer. The water used for the pressurized water is preferably ordinary water, namely, industrial water, and may be purified water or distilled water. Further, water obtained by recycling wastewater used in various industrial production processes may be used. Further, the water may be water obtained by recycling wastewater after use in carrying out the fourth exemplary embodiment (e.g., the recycled water W2 in Figs. 1A, 3, and 4). When wastewater is recycled, the wastewater may be subjected to treatment for recycling, as appropriate.

The water used for the pressurized water may contain an additive for imparting functionality, as appropriate, but preferably does not contain such an additive. Examples of the additive include an antistatic agent, a surfactant, and a water-soluble organic solvent. When the water used for the pressurized water contains an additive, the concentration of an active ingredient of the additive in the water is preferably 0.2 mass% or less, more preferably 0.1 mass% or less, relative to the total amount of the water, and still more preferably, the water used for the pressurized water is not water to which an additive has been intentionally added.

Further, the water used for the pressurized water is preferably neither an alkaline aqueous solution prepared by intentionally adding a basic substance nor an acidic aqueous solution prepared by intentionally adding an acidic substance. Since wastewater may possibly be treated by a simple recycling treatment, the water used for the pressurized water may contain a basic substance and an acidic substance as additives. In such a case, the pH of the pressurized water is preferably in a range from 5.8 to 8.6 so as to comply with the uniform effluent standards (other items) under the Water Pollution Prevention Act.

The temperature of the pressurized water is not particularly limited. The

temperature of the pressurized water may be room temperature.

[0045]

Unwinding Step

The unwinding step is a step of unwinding the laminated film including the base film and the coating layer from the roll around which the laminated film is wound.

As the laminated film, for example, the laminated film 90 illustrated in Fig. 2 can be used.

The laminated film 90 may be a laminated film that has been used in the production of a ceramic green sheet and from which a required portion of the ceramic green sheet has been peeled off.

[0046]

First Jet-Spraying Step and Second Jet-Spraying Step

In the first jet-spraying step, pressurized water is jet-sprayed toward the first jet-spray region of the coating layer to fracture the coating layer when the unwound laminated film passes at least one backup roller.

In the second jet-spraying step, after the first jet-spraying step, pressurized water is jet-sprayed toward the second jet-spray region of the coating layer that includes at least a region other than the first jet-spray region when the laminated film passes the at least one backup roller, to fracture the coating layer in the second jet-spray region that has not been fractured in the first jet-spraying step.

Preferably, the first jet-spraying step is a step of jet-spraying pressurized water from the first jet-spray unit including one or more nozzles disposed to face the at least one backup roller, and the second jet-spraying step is a step of jet-spraying pressurized water from the second jet-spray unit including one or more nozzles disposed to face the at least one backup roller.

In the cases of Figs. 1A, 1B, and 1C, in the first jet-spraying step, pressurized water W3 is jet-sprayed from the first jet-spray unit 31 including five nozzles disposed to face the first backup roller 21.

The first jet-spraying step is performed in a state in which the first backup roller 21 abuts a surface of the base film 91 of the laminated film 90 opposite the coating layer 92.

In the second jet-spraying step, pressurized water W3 is jet-sprayed from the

second jet-spray unit 32 including four nozzles disposed to face the second backup roller 22. The second jet-spraying step is performed in a state in which the second backup roller 22 abuts a surface of the base film 91 of the laminated film 90 opposite the coating layer 92.

[0047]

In the first jet-spraying step and the second jet-spraying step, the nozzle pressure is preferably in a range from 3.0 MPa to 70 MPa, more preferably in a range from 10 MPa to 50 MPa. The nozzle pressure used in the first jet-spraying step and the nozzle pressure used in the second jet-spraying step may be the same as or different from each other.

[0048]

In the fourth exemplary embodiment, for each of the first jet-spraying step and the second jet-spraying step, a corresponding backup roller among the at least one backup roller supports the laminated film during the corresponding jet-spraying step, and, when viewed in a cross section perpendicular to a central axis of the corresponding backup roller, a jet-spraying direction of the pressurized water from the corresponding one of the first jet-spray unit and the second jet-spray unit is preferably perpendicular to a peripheral tangent of the corresponding backup roller (e.g., PT1 and PT2 in the case of Fig. 1A).

[0049]

Wash-Away Step

The wash-away step is a step of washing away the fractured coating layer together with the pressurized water W3 jet-sprayed toward the first jet-spray region and the second jet-spray region.

The wash-away step is a step of washing away at least a part of the fractured coating layer.

In the case of Fig. 1A, in the wash-away step, the coating layer 92 fractured by the jet-spraying of the pressurized water W3 from the first jet-spray unit 31 is washed away together with the pressurized water W3, and thereafter, the coating layer 92 fractured by the jet-spraying of the pressurized water W3 from the second jet-spray unit 32 is washed away together with the pressurized water W3. The coating layer 92 that has been washed away is discharged through the discharge outlets 1a,

2a of the jet-spray chambers 301, 302, respectively.

In the wash-away step, as in the third exemplary embodiment, by jet-spraying the pressurized water W3 toward the coating layer 92 from the jet-spray units 31, 32 disposed below the first backup roller 21 (in the −Z-axis direction), the fractured coating layer 92 is more readily washed away (more readily falls off).

[0050]

Coating Layer Removal Step

In the fourth exemplary embodiment, a coating layer removal step of removing residue of the coating layer is preferably performed after the wash-away step and before the winding step.

The coating layer removal step is a step of removing residue of the coating layer that has not been washed away in the wash-away step.

Examples of the step of removing residue of the coating layer include a step of blowing off the coating layer 92 remaining in a fractured state on the base film 91 and a step of drying water adhering to the base film 91.

In the case of Fig. 1A, in the coating layer removal step, air is blown from a pair of blow-off nozzles (an example of the residue removal apparatus 70) onto both surfaces of the laminated film 90 discharged from the second jet-spray chamber 302 to blow off the fractured coating layer, thereby removing residue of the coating layer.

[0051]

Recovery Step and Reuse Step

The removal method according to the fourth exemplary embodiment preferably includes a step of recovering water used in the first jet-spraying step and the second jet-spraying step, and a step of reusing at least a portion of the recovered water in the first jet-spraying step and the second jet-spraying step.

In the case of Fig. 1A, the water jet-sprayed from the first jet-spray unit 31 and the second jet-spray unit 32 is discharged through the discharge outlets 1a, 2a of the jet-spray chambers 301, 302, respectively, and is filtered through the filters 601, 602 and recycled. The filtered water (recycled water W2) is supplied to the second tank 63 by the recovery pumps 61, 62 (recovery step). The recycled water W2 is used by the pressurized-water supply unit 50 to generate pressurized water and is reused in the first jet-spraying step and the second jet-spraying step (reuse

step).

[0052]

Winding Step

In the winding step, the base film from which the coating layer has been removed is wound into a roll. In the case of Fig. 1A, the base film 91 is wound into a roll by the roll winding shaft 40. The wound base film 91 can be recycled into a resin forming the base film 91 by, for example, material recycling or chemical recycling.

[0053]

Modification of Embodiment(s)

In the removal apparatuses according to the exemplary embodiments described above, an exemplary arrangement including two jet-spray units (the first jet-spray unit 31 and the second jet-spray unit 32) has been described; however, the removal apparatus may include, for example, three or more jet-spray units. The number of jet-spray units is, for example, in a range from 2 to 20, preferably in a range from 2 to 10. The two or more jet-spray units may, for example, all be disposed to face one backup roller, as illustrated in Figs. 3 and 4, or may be distributed among two or more backup rollers and disposed to face the respective backup rollers, as illustrated in Fig. 1A.

[0054]

An example of an arrangement including five jet-spray units will be described with reference to Fig. 5.

Fig. 5 illustrates the respective nozzles and the laminated film as viewed from the proximal end side of the nozzles toward the nozzle tips (jet outlets). The first jet-spray unit 31, the second jet-spray unit 32, the third jet-spray unit 33, the fourth jet-spray unit 34, and the fifth jet-spray unit 35 are disposed in this order from the upstream side in the conveyance direction (+X-axis direction) of the laminated film 90.

One nozzle 31a of the first jet-spray unit 31 is disposed at the center of the laminated film in the width direction (Y-axis direction); two nozzles 32a, 32b of the second jet-spray unit 32 are disposed on the −Y-axis direction side and the +Y-axis direction side, respectively, relative to the nozzle 31a; two nozzles 33a, 33b of the third jet-spray unit 33 are disposed on the −Y-axis direction side and the +Y-axis

direction side, respectively, relative to the nozzles 32a, 32b; two nozzles 34a, 34b of the fourth jet-spray unit 34 are disposed on the −Y-axis direction side and the +Y-axis direction side, respectively, relative to the nozzles 33a, 33b; and two nozzles 35a, 35b of the fifth jet-spray unit 35 are disposed on the −Y-axis direction side and the +Y-axis direction side, respectively, relative to the nozzles 34a, 34b.

As illustrated in Fig. 5, the nozzle 31a of the first jet-spray unit 31 is disposed at the center of the laminated film in the width direction, and the nozzles of the second jet-spray unit 32 to the fifth jet-spray unit 35 are arranged at positions progressively farther from the center toward both ends of the laminated film 90 in the width direction (the −Y-axis direction and the +Y-axis direction), thereby forming an inverted V-shaped arrangement, whereby the following effects are achieved.

In each of the jet-spray units other than the leading first jet-spray unit 31 (the second jet-spray unit 32 to the fifth jet-spray unit 35 in the case of Fig. 5), when the pressurized water impinges on the coating layer 92, the coating layer 92 has already been fractured in a jet-spray region downstream of the jet-spray unit. Therefore, the fractured portion serves as a starting point from which the coating layer 92 is more readily fractured by the jet-spray unit. Accordingly, the pressure of the pressurized water can be reduced for the jet-spray units other than the first jet-spray unit 31, which may result in energy savings. Further, by arranging the jet-spray units as illustrated in Fig. 5, the fractured coating layer can be naturally washed away toward both ends of the laminated film 90 in the width direction, thereby reducing the load on the residue removal apparatus 70.

[0055]

In the removal apparatuses according to the exemplary embodiments described above, regions on which the pressurized water jet-sprayed from nozzles of different jet-spray units impinges may partially overlap each other within a range that does not impair the effects of the exemplary embodiments.

[0056]

In the removal apparatuses according to the exemplary embodiments described above, an exemplary arrangement in which the pressurized-water supply unit 50 uses both the water W1 stored in the first tank 53 and the recycled water W2 stored in the second tank 63 has been described; however, the pressurized-water

supply unit 50 may generate pressurized water using either the water W1 or the recycled water W2. The pressurized-water supply unit 50 need only include at least one pump configured to supply pressurized water to the respective jet-spray units.

[0057]

In the removal apparatuses according to the exemplary embodiments described above, an exemplary arrangement including the residue removal apparatus 70 has been described; however, the residue removal apparatus 70 is optional. The removal apparatuses according to the exemplary embodiments described above need not include the residue removal apparatus 70.

[0058]

In the removal method according to the exemplary embodiment described above, an exemplary arrangement in which the coating layer is removed using the removal apparatus (Figs. 1A, 3, and 4) including both the roll unwinding shaft 10 and the roll winding shaft 40 has been described; however, instead of the removal apparatus, an apparatus system in which an apparatus that performs a preceding process (e.g., a green sheet laminating apparatus) and the removal apparatus according to the exemplary embodiment described above are integrated may be used.

In the following description, the apparatus that performs the preceding process is referred to as a “preceding-process apparatus,” and the removal apparatus according to the exemplary embodiment described above is referred to as a “removal apparatus,” and specific examples of the apparatus system will be described.

When the removal method according to the exemplary embodiment described above is applied, one example is to apply the removal method according to the exemplary embodiment described above to a combination of apparatuses in which the preceding-process apparatus includes (a) a roll unwinding shaft for the preceding-process apparatus and (b) a roll winding shaft for the preceding-process apparatus, and the removal apparatus includes (c) a roll unwinding shaft for the removal apparatus (reference sign 10 in Figs. 1A, 3, and 4) and (d) a roll winding shaft for the removal apparatus (reference sign 40 in Figs. 1A, 3, and 4). In contrast, in the present modification, the removal method according to the exemplary

embodiment described above is applied to, as the apparatus system, for example, an integrated apparatus in which the preceding-process apparatus and the removal apparatus are connected to each other, with the roll winding shaft (b) and the roll unwinding shaft (c) omitted. In the present modification, the step of unwinding the laminated film is performed by the roll unwinding shaft (a) of the preceding-process apparatus.

By carrying out the removal method according to the exemplary embodiment described above using such an apparatus system (integrated apparatus), a process for producing a multilayer ceramic capacitor (MLCC) and the coating layer removal process can be continuously performed in an integrated roll-to-roll process, thereby making it possible to significantly reduce operating costs.

[0059]

The invention is by no means limited to the above exemplary embodiments. The invention can encompass any modifications, improvements, and the like within the scope of the invention that the object of the invention is achievable.

[0060]

A configuration of the laminated film will be described.

[0061]

Laminated Film

The laminated film used in the above exemplary embodiments includes the base film and the coating layer. The coating layer is a single layer or or a multilayer formed of two or more coating layers of the same or different materials.

In order to facilitate removing the coating layer from the laminated film and collecting the remaining base film, the base film and the coating layer of the laminated film are preferably directly laminated. Herein, the term “directly laminated” means that, for instance, no layer is interposed between the base film and the coating layer, where the base film and the coating layer are in direct contact with each other.

[0062]

Base Film

As the base film, a resin film formed of a resin component planned to be collected is used. Examples of the resin film include: polyester films such as a polyethylene terephthalate film, polybutylene terephthalate film, and polyethylene

naphthalate film; polyolefin films such as a polyethylene film and polypropylene film; polyimide film; polyamide film; polycarbonate film; polyacetate film; ethylene-vinyl acetate (EVA) film; ethylene-(meth)acrylic acid copolymer film; ethylene-(meth)acrylate copolymer film; cycloolefin polymer film; polyurethane film; polyphenylene sulfide film; and cellophane.

Among various films usable as the base film, polyester film is preferable in terms of excellent heat resistance and strength. In terms of facilitating collecting and recycling of resins, the polyester film is preferably a film whose main component is any of polyethylene terephthalate, polybutylene terephthalate, and polyethylene naphthalate. Herein, a main constituent or a main component means a constituent or component accounting for 50 mass% or more of the total mass of the material.

The resin film optionally additionally contains known filler(s), coloring agent(s), antistatic agent(s), antioxidant(s), organic lubricant(s), catalyst(s), and the like. The resin film is optionally transparent, or colored or the like as desired. At least one of the surfaces of the base film is optionally subjected in advance to a surface treatment, for instance, sputtering, corona discharge, flame treatment, ultraviolet irradiation, electron beam irradiation, or etching such as oxidation treatment, as necessary.

[0063]

A thickness of the base film, which is not particularly limited, is preferably in a range from 10 μm to 500 μm, more preferably from 15 μm to 300 μm, and still more preferably from 20 μm to 200 μm in terms of strength, rigidity, and the like.

[0064]

Coating Layer

The coating layer is preferably a functional layer. Examples of the functional layer include a release agent layer, print layer, hard coat layer, easy-adhesion layer, and adhesive layer. Among the above, the coating layer is preferably a release agent layer.

When the coating layer is a release agent layer, the release agent layer is preferably formed of a release agent composition.

The release agent composition to be used for forming the release agent layer is not particularly limited as long as the release agent composition exhibits

releasability. For instance, a release agent composition whose main component is a silicone compound, a fluorine compound, a compound including a long-chain alkyl group, a thermoplastic resin material such as an olefin resin and diene resin is usable. It is also preferable to use a release agent composition whose main component is an energy-ray curing resin or a thermosetting resin. One of the above release agent compositions may be used alone, or two or more of the above may be used in combination.

[0065]

In a release agent composition whose main component is a silicone compound, an example of the silicone compound is a silicone compound including organopolysiloxane as a basic skeleton. Examples of the silicone compounds include thermosetting silicone compounds such as addition-reaction-type silicone compounds and condensation-reaction-type silicone compounds, and energy-ray-curable silicone compounds such as ultraviolet-curable silicone compounds and electron-beam-curable silicone compounds.

[0066]

In a release agent composition whose main component is a fluorine compound, examples of the fluorine compound include a fluorosilicone compound, a fluoroboron compound, and a compound including a poly(perfluoroalkylene ether) chain.

[0067]

In a release agent composition whose main component is a compound including a long-chain alkyl group, examples of the compound including a long-chain alkyl group include polyvinyl carbamate produced by reacting long-chain alkyl isocyanate with a polyvinyl alcohol polymer, alkyl urea derivative produced by reacting long-chain alkyl isocyanate with polyethylene imine, and long-chain alkyl (meth)acrylate copolymer. Additionally, a long-chain alkyl-modified alkyd resin, which is produced by applying a long-chain fatty acid as a modifying agent to an alkyd resin produced by condensation reaction of a polyvalent alcohol and a polybasic acid, is optionally used.

[0068]

Preferable example of the release agent composition whose main

component is an energy-ray curing resin is a composition containing polyorganosiloxane and an energy-ray curing compound including a reactive functional group selected from a (meth)acryloyl group, alkenyl group, and maleimide group. In the release agent layer formed of the above-described release agent composition that uses energy-ray curing compound and polyorganosiloxane whose molecular structures, polarity, and molecular weights are mutually different, before the release agent layer is cured, the component derived from polyorganosiloxane segregates near an outer surface of the release agent layer to be subsequently cured by an energy beam to stabilize the segregation. As a result, releasability of the release agent layer can be improved. The release agent composition whose main component is an energy-ray curing resin optionally further contains a photoinitiator.

[0069]

Examples of a release agent composition whose main component is a thermosetting resin include a release agent composition whose main component is a melamine resin and a release agent composition whose main component is an epoxy resin. An example of a release agent composition whose main component is a melamine resin is a composition containing a melamine resin (base compound), an acid catalyst for thermally curing the melamine resin, and polyorganosiloxane that provides releasability for the release agent layer. An example of a release agent composition whose main component is an epoxy resin is a composition containing an epoxy resin (base compound), an acidic or basic thermosetting catalyst for thermally curing the epoxy resin, and polyorganosiloxane that provides releasability for the release agent layer. The component derived from polyorganosiloxane segregates at and near an outer surface of the release agent layer before the release agent layer is cured, and is subsequently cured to stabilize the segregation. As a result, releasability of the release agent layer can be improved.

[0070]

The coating layer optionally contains an additive in addition to the above-described resin components. Examples of the additional additive include an anti-aging agent, light stabilizer, flame retardant, conducting agent, antistatic agent, and plasticizer.

[0071]

A thickness of the coating layer, which is designed as desired and not particularly limited, is preferably in a range from 0.02 μm to 5 μm, more preferably from 0.03 μm to 2 μm, and still more preferably from 0.05 μm to 1.5 μm.

[0072]

The laminated film used in each of the exemplary embodiments is usually usable in order to protect a surface of functional sheets and components usable in specific applications when the functional sheets and components are produced, transported, stored, and the like. After being used for protecting the components and the like, the laminated film are peeled off from the surface and are often disposed. With the use of the laminated film, the coating layer can be easily separated from the base film of the laminated film, thereby greatly contributing to resource protection and environment protection.

EXPLANATION OF CODES

[0073]

10…roll unwinding shaft, 21…first backup roller, 22…second backup roller, 31…first jet-spray unit, 32…second jet-spray unit, 33…third jet-spray unit, 34…fourth jet-spray unit, 35…fifth jet-spray unit, 40…roll winding shaft, 50…pressurized-water supply unit, 51…first supply pump, 52…second supply pump, 53…first tank, 54…pipe, 55…water supply source, 60, 60A…water recovery and recycling apparatus, 61…first recovery pump, 62…second recovery pump, 63…second tank, 70…residue removal apparatus, 80…residue detection apparatus, 90…laminated film, 91…base film, 92…coating layer, 100, 100A, 100B…removal apparatus, 301…first jet-spray chamber, 302…second jet-spray chamber, 511, 521, 531, 532, 631, 632…pipe, 601…first filter, 602…second filter, 1a, 2a…discharge outlet, 21a, 22a…central axis, 31a to 31e, 32a to 32d, 33a to 33b, 34a to 34b, 35a to 35b…nozzle

CLAIM(S)

[Claim 1]

A coating layer removal apparatus configured to remove a coating layer from a laminated film including a base film and the coating layer, the removal apparatus comprising:

a roll unwinding shaft configured to unwind the laminated film;

a first backup roller disposed downstream of the roll unwinding shaft, configured to abut the base film of the laminated film, and configured to convey the laminated film downstream;

a first jet-spray unit including one or more nozzles disposed to face the first backup roller;

a second jet-spray unit disposed downstream of the first jet-spray unit and including one or more nozzles disposed to face either the first backup roller or a second backup roller different from the first backup roller;

a pressurized-water supply unit configured to pressurize water and supply the pressurized water to the first jet-spray unit and the second jet-spray unit; and

a roll winding shaft configured to wind the base film, from which the coating layer has been removed, into a roll, wherein

the pressurized-water supply unit includes one or more pumps, and

each of the first jet-spray unit and the second jet-spray unit is connected to at least one of the one or more pumps.

[Claim 2]

The coating layer removal apparatus according to claim 1, wherein, when viewed along a conveyance direction of the laminated film, the one or more nozzles included in the first jet-spray unit and the one or more nozzles included in the second jet-spray unit are arranged in a staggered manner such that at least some of the nozzles do not overlap each other in the conveyance direction of the laminated film.

[Claim 3]

The coating layer removal apparatus according to claim 1 or 2, wherein, when at least one of the first jet-spray unit or the second jet-spray unit includes a plurality of nozzles, the plurality of nozzles are arranged along at least one direction intersecting the conveyance direction of the laminated film.

[Claim 4]

The coating layer removal apparatus according to claim 1 or 2, wherein the second jet-spray unit is disposed such that pressurized water impinges on a region of the laminated film on which the pressurized water jet-sprayed from the first jet-spray unit does not impinge.

[Claim 5]

The coating layer removal apparatus according to claim 1 or 2, further comprising a water recovery and recycling apparatus configured to recover and recycle water jet-sprayed from the first jet-spray unit and the second jet-spray unit, wherein

the water recovery and recycling apparatus is connected to the pressurized-water supply unit.

[Claim 6]

The coating layer removal apparatus according to claim 1 or 2, further comprising a residue detection apparatus configured to detect residue of the coating layer, wherein

the residue detection apparatus is disposed downstream of the second backup roller and upstream of the roll winding shaft.

[Claim 7]

The coating layer removal apparatus according to claim 1 or 2, further comprising a residue removal apparatus configured to remove residue of the coating layer, wherein

the residue removal apparatus is disposed downstream of the second backup roller and upstream of the roll winding shaft.

[Claim 8]

A coating layer removal method comprising:

unwinding, from a roll around which a laminated film including a base film and a coating layer is wound, the laminated film;

performing first jet-spraying by jet-spraying pressurized water toward a first jet-spray region of the coating layer when the unwound laminated film passes at least one backup roller, thereby fracturing the coating layer;

after the first jet-spraying, performing second jet-spraying by jet-spraying

pressurized water toward a second jet-spray region of the coating layer including at least a region other than the first jet-spray region when the laminated film passes the at least one backup roller, thereby fracturing the coating layer in the second jet-spray region that is not fractured by the first jet-spraying;

washing away the fractured coating layer; and

winding, into a roll, the base film after the coating layer is washed away.

[Claim 9]

The coating layer removal method according to claim 8, wherein

the first jet-spraying is performed by jet-spraying pressurized water from a first jet-spray unit including one or more nozzles disposed to face the at least one backup roller;

the second jet-spraying is performed by jet-spraying pressurized water from a second jet-spray unit including one or more nozzles disposed to face the at least one backup roller; and

for each of the first jet-spraying and the second jet-spraying, a corresponding backup roller among the at least one backup roller supports the laminated film during the corresponding jet-spraying, and, when viewed in a cross section perpendicular to a central axis of the corresponding backup roller, a jet-spraying direction of the pressurized water from the corresponding one of the first jet-spray unit and the second jet-spray unit is perpendicular to a peripheral tangent of the corresponding backup roller.

[Claim 10]

The coating layer removal method according to claim 8 or 9, further comprising removing residue of the coating layer after washing away the fractured coating layer and before winding the base film into a roll.

[Claim 11]

The coating layer removal method according to claim 8 or 9, further comprising:

recovering water used in the first jet-spraying and the second jet-spraying; and

reusing at least a portion of the recovered water in the first jet-spraying and the second jet-spraying.