

DESCRIPTION

SOLID POLYMER SEPARATOR

5 TECHNICAL FIELD

[0001]

The present invention relates to a means that separates a solid polymer dispersed in a liquid from the liquid.

10 BACKGROUND ART

[0002]

A process that removes a solid (e.g., particulate solid) dispersed in a liquid from the liquid to collect the solid is normally used in the fields of chemical industry, food industry, mining industry, and the like.

15 [0003]

For example, when producing a rubber product, steam (water vapor) is applied to a polymer (polymer material) dissolved in a solvent to remove the solvent from the polymer. The polymer is then granulated using a granulator to obtain small solid masses (solid polymer (hereinafter may be referred to as “crumbs”)). The crumbs (solid polymer) are dispersed in boiling water (liquid) heated by steam. The crumbs are then separated from the boiling water, optionally dehydrated/dried, and press-molded to obtain a block rubber material (intermediate product).

[0004]

25 A stationary screen or a circulating screen has been used to separate crumbs from boiling water when producing a rubber product.

[0005]

The term “stationary screen” used herein refers to a flat metal screen that is

secured in a state in which the screen is tilted relative to the horizontal plane, for example. When boiling water that contains crumbs dispersed therein is supplied to the flat screen, the boiling water passes through the mesh of the flat screen, while the crumbs remain on the flat screen, and fall off from the tilted flat screen. The crumbs
5 can thus be separated from the boiling water.

[0006]

The term “circulating screen” used herein refers to a an endless screen that is formed by combining a number of metal plates (see Patent Document 1). When boiling water that contains crumbs dispersed therein is supplied to the endless screen,
10 the boiling water passes through the slits formed by the metal plates, while the crumbs remain on the endless screen, transferred in a given direction, and leave the endless screen. The crumbs can thus be separated from the boiling water.

RELATED-ART DOCUMENT

PATENT DOCUMENT

15 [0007]

Patent Document 1: JP-A-6-304417

SUMMARY OF THE INVENTION

[0008]

20 However, the following problems may occur when separating crumbs from boiling water using such a stationary screen or circulating screen.

[0009]

Specifically, when using the stationary screen, crumbs having a diameter may enter and clog the mesh of the flat screen. In this case, the boiling water separation
25 effect may decrease, and a large amount of free water may be supplied to the subsequent dehydration/drying step together with the crumbs. As a result, water may not be sufficiently removed from the crumbs even if the dehydration/drying step is

performed, and the resulting block rubber material (intermediate product) may have a high water content.

[0010]

There may be a case where crumbs may adhere to the crumbs that are already
5 adhering to the mesh, so that large crumbs may be produced. Such large crumbs may
be removed from the mesh, and supplied to the subsequent dehydration/drying step. In
this case, transfer failure may occur during dehydration/drying step, and it may be
necessary to suspend the process (production process). Moreover, since
dehydration/drying may become insufficient, the resulting block rubber material
10 (intermediate product) may have a high water content.

[0011]

The above problems tend to occur when the polymer has high adhesion or
aggregation properties, or the diameter of the crumbs is reduced depending on the
specification of the rubber product. The above problems may be solved by replacing
15 the screen every 10 to 15 days, for example. However, such regular replacement work
takes time. Moreover, since it is necessary to suspend the process (production process)
during the replacement work, the intermediate product production efficiency decreases.
The screen replacement frequency may be reduced by performing high-pressure
washing every 15 to 30 minutes, for example. However, such regular washing work
20 also takes time.

[0012]

The following problems may occur when using the circulating screen.
Specifically, since the metal plates that form the slits come in slide contact with each
other when the metal plates are driven, the metals come in contact with each other
25 (metal touch), to a large extent. Therefore, the metal may be mixed into the crumbs
and the block rubber material (intermediate product).

[0013]

The circulating screen also has a problem in that the metal plates that form the endless screen may expand, and may become non-parallel to each other. This makes it necessary to regularly adjust tension or position. The element (e.g., bush) of a chain that drives the endless screen may deteriorate during continuous long-term use. It may
5 be necessary to replace the entire chain or the element (e.g., bush) of the chain depending on the degree of deterioration. Such adjustment or replacement work requires skill and time, and make it necessary to perform a trial run for a long time. Moreover, since it is necessary to suspend the process (production process) during the adjustment/replacement work or trial run, the intermediate product production
10 efficiency decreases. The chain also undergoes a metal contact situation. Therefore, the metal may be mixed into the crumbs and the block rubber material (intermediate product).

[0014]

The present invention was conceived in view of the above situation. An object
15 of the invention is to provide a means that can advantageously separate crumbs from boiling water, and can separate a solid polymer dispersed in a liquid from the liquid. Another object of the invention is to provide a means that ensures that a metal or a large amount of water is not contained in a block rubber material (intermediate product) by preventing a situation in which a metal is mixed into crumbs (solid polymer) or a large
20 amount of water (boiling water or liquid) remains in crumbs (solid polymer). A further object of the invention is to provide a means that does not (frequently) require cleaning work, adjustment work, replacement work, and the like, and makes it possible to continue a production process for a long time. The inventor of the invention conducted extensive studies, and found that the above objects can be achieved by the
25 following means. This finding has led to the completion of the present invention.

[0015]

According to one aspect of the present invention, there is provided a solid

polymer separator that separates a solid polymer dispersed in a liquid from the liquid, the solid polymer separator including: a tubular screen in which a number of slits are formed; a drive mechanism that rotates the screen (in a circumferential direction); a guide plate that is provided along an inner circumferential surface of the screen; a first liquid spray mechanism that is provided over an outer circumferential surface of the screen, and sprays a liquid to the outer circumferential surface of the screen; and a casing that encloses at least the screen, and has an outlet that is provided on a lower side.

[0016]

10 In the tubular screen, a number of slits may be formed by arranging a plurality of wires in parallel to form the outer circumferential surface of the tubular screen. The width of the slit (i.e., the interval between the wires) may arbitrarily be set depending on the size of the solid polymer (processing target). The width of the slit is preferably 1 to 3 mm, and particularly preferably 1.5 to 2.5 mm, taking account of screen cleaning work. It is particularly preferable that the screen have a cylindrical shape. In this case, the drive mechanism rotates the screen in the circumferential direction of a circle.

[0017]

The drive mechanism includes a drive source and a drive power transfer mechanism, for example. More specifically, the drive mechanism may include an electric motor (drive source), a sprocket that is connected to the electric motor, a drive tube that is connected to the inlet side of the tubular screen, a chain that is fitted around the circumferential surface of the drive tube, and a roller (drive power transfer mechanism) that is provided to come in contact with the drive tube. The drive tube and the screen are rotated by rotating the sprocket connected to the electric motor to rotate the chain. When the drive tube and the screen are placed on the roller, the drive tube and the screen rotate smoothly.

[0018]

The guide plate is provided along the inner circumferential surface of the screen from the inlet side to the outlet side of the tubular screen. It is preferable that the guide plate have a spiral shape. The guide plate having a spiral shape functions as a partition for the solid polymer (processing target), and forms a groove. When an extension tube described later is provided, it is preferable to also provide the guide plate along the extension tube. The guide plate is formed either continuously or intermittently. It is preferable that the guide plate be formed continuously. When the guide plate has a spiral shape, the number of threads of the guide plate may arbitrarily be set depending on the processing amount (mass per unit time) of the solid polymer (processing target), and the supply state of the crumbs to a dehydration/drying step. The number of threads of the guide plate having a spiral shape is preferably 4 to 8, and particularly preferably 5 to 7, taking account of screen cleaning work. The height of the guide plate having a spiral shape may arbitrarily be set depending on the processing amount (mass per unit time) of the solid polymer (processing target). The height of the guide plate having a spiral shape is preferably 5 to 15 cm, and particularly preferably 8 to 12 cm, taking account of screen cleaning work.

[0019]

The term “inlet side” used herein refers to a side where the processing target liquid and the solid polymer dispersed in the processing target liquid are supplied. The term “outlet side” used herein refers to a side where the processed solid polymer (i.e., the solid polymer that has been separated from the liquid) is discharged. Note that the terms “inlet side” and “outlet side” are used herein in connection with the tubular screen, the entire solid polymer separator, and the elements other than the screen.

[0020]

When the guide plate has a spiral shape, the screen is rotated in the circumferential direction of the screen that corresponds to the spiral direction of the guide plate. The solid polymer dispersed in the liquid is continuously supplied

through one opening (inlet) of the tubular screen. In this case, the liquid passes through the slits, and is discharged to the outside of the system through the outlet provided on the lower side of the casing. On the other hand, the solid polymer is separated from the liquid, and remains on the inner circumferential surface of the tubular screen. The solid polymer is discharged through the other opening (outlet) of the screen in a constant amount at constant intervals while being guided by the guide plate having a spiral shape.

[0021]

The first liquid spray mechanism is provided on the side of the outer circumferential surface of the screen, and sprays a liquid to the outer circumferential surface of the screen. For example, the first liquid spray mechanism is secured on the upper side of the casing so that the first liquid spray mechanism discharges a liquid over the outer circumferential surface of the screen. Adhesion and aggregation of the solid polymer can be prevented by spraying a liquid to the outer circumferential surface of the screen from the first liquid spray mechanism. It is also possible to remove the solid polymer that adheres to the screen from the screen. The number of first liquid spray mechanisms may arbitrarily be set corresponding to the length of the tubular screen (in the axial direction). The number of first liquid spray mechanisms is preferably 3 to 15, and particularly preferably 5 to 10 per meter of the screen, taking account of screen cleaning work.

[0022]

It is preferable that the solid polymer separator according to one aspect of the present invention further include a second liquid spray mechanism that is provided on the outlet side of the tubular screen, and sprays a liquid to the inner circumferential surface of the screen in the upward direction.

[0023]

The second liquid spray mechanism is provided on the outlet side of the tubular

screen, and sprays a liquid to the inner circumferential surface of the screen in the upward direction. For example, the second liquid spray mechanism is secured using a support or plumbing so that the second liquid spray mechanism sprays a liquid toward the inner circumferential surface of the screen in the upward direction, and the spray
5 orifice is positioned at the center of the plane (circle) perpendicular to the axial direction of the tubular screen in the vicinity of the outlet of the tubular screen.

Adhesion and aggregation of the solid polymer can be prevented by spraying a liquid to the inner circumferential surface of the screen in the upward direction from the second liquid spray mechanism. It is also possible to remove the solid polymer that adheres to
10 the screen from the screen. The number of second liquid spray mechanisms may arbitrarily be set corresponding to the length of the tubular screen (in the axial direction) and the size (area) of the inner circumferential surface of the tubular screen. The number of second liquid spray mechanisms is preferably 1 to 5, and particularly preferably 2 to 4, taking account of screen cleaning work.

15 [0024]

It is preferable that the solid polymer separator according to one aspect of the present invention further include a third liquid spray mechanism that is provided in the upper area of the casing, and sprays a liquid to the inner side of the casing.

[0025]

20 For example, the third liquid spray mechanism is secured on the top side (inner side) of the casing, or the corner where the top side and the side surface intersect, so that the third liquid spray mechanism sprays a liquid toward the inner side of the casing. Adhesion and aggregation of the solid polymer can be prevented by spraying a liquid to the inner side (particularly the top side and the upper part of the side surface) of the
25 casing from the third liquid spray mechanism. It is also possible to remove the solid polymer that adheres to the casing from the casing. The number of third liquid spray mechanisms may arbitrarily be set corresponding to the size (i.e., the area of the inner

side) of the casing. The number of third liquid spray mechanisms is preferably 4 to 16, and particularly preferably 8 to 14, taking account of casing inner side cleaning work.

[0026]

It is preferable that the solid polymer separator according to one aspect of the present invention further include a fourth liquid spray mechanism that is provided in the lower area of the casing, and sprays a liquid to the inner side of the casing.

[0027]

For example, the fourth liquid spray mechanism is secured on the corner where the bottom and the side surface of the casing intersect, so that the fourth liquid spray mechanism sprays a liquid toward the inner side of the casing. Adhesion and aggregation of the solid polymer can be prevented by spraying a liquid to the inner side (particularly the bottom and the lower side surface) of the casing from the fourth liquid spray mechanism. It is also possible to remove the solid polymer that adheres to the casing from the casing. The number of fourth liquid spray mechanisms may arbitrarily be set corresponding to the size (i.e., the area of the inner side (particularly the bottom)) of the casing. The number of fourth liquid spray mechanisms is preferably 4 to 10, and particularly preferably 6 to 8, taking account of casing bottom cleaning work.

[0028]

It is preferable that the solid polymer separator according to one aspect of the present invention further include an extension tube that is connected to the outlet side of the tubular screen, and a fifth liquid spray mechanism that is provided on the outlet side of the tubular screen, and sprays a liquid to the inner circumferential surface of the extension tube in the downward direction.

[0029]

For example, the fifth liquid spray mechanism is secured using a support or plumbing so that the fifth liquid spray mechanism sprays a liquid toward the inner circumferential surface of the extension tube in the downward direction, and the spray

orifice is positioned at the center of the plane (circle) perpendicular to the axial direction of the tubular screen in the vicinity of the outlet of the tubular screen (i.e., in the vicinity of the extension tube). Adhesion of the solid polymer can be prevented by spraying a liquid to the inner circumferential surface of the extension tube in the downward direction from the fifth liquid spray mechanism. It is also possible to cool the solid polymer transferred to the subsequent step (e.g., dehydration/drying) by utilizing cold water as the liquid. The number of fifth liquid spray mechanisms may arbitrarily be set corresponding to the size (area) of the inner circumferential surface of the extension tube. The number of fifth liquid spray mechanisms is preferably 1 to 5, and particularly preferably 2 to 4, taking account of extension tube cleaning work.

[0030]

The pressure of the liquid sprayed from the first liquid spray mechanism, the third liquid spray mechanism, and the fourth liquid spray mechanism is preferably as high as possible taking account of cleaning work. The liquid pressure is preferably 1 to 7 MPa taking account of the strength of the liquid-spray target (e.g., screen), and the resistance to the rotation of the screen.

[0031]

The pressure of the liquid sprayed from the second liquid spray mechanism need not be as high as the pressure of the liquid sprayed from the first liquid spray mechanism, the third liquid spray mechanism, and the fourth liquid spray mechanism taking account of scattering of the crumbs inside the screen, for example. The pressure of the liquid sprayed from the second liquid spray mechanism is preferably about 0.2 to 0.6 MPa.

[0032]

The temperature of the liquid sprayed from the first liquid spray mechanism, the second liquid spray mechanism, the third liquid spray mechanism, and the fourth liquid spray mechanism may arbitrarily be set depending on the temperature dependence of

the properties (e.g., hardness, viscosity, adhesion, and aggregation properties) of the solid polymer (processing target). The liquid temperature is preferably 50 to 95°C, and particularly preferably 70 to 90°C, taking account of the adhesion (or removability) of the solid polymer.

5 [0033]

The pressure of the liquid sprayed from the fifth liquid spray mechanism may be 0.1 to 0.6 MPa. The temperature of the liquid sprayed from the fifth liquid spray mechanism is preferably 5 to 40°C, and particularly preferably 15 to 30°C.

[0034]

10 The first liquid spray mechanism, the second liquid spray mechanism, the third liquid spray mechanism, the fourth liquid spray mechanism, and the fifth liquid spray mechanism respectively include a spray nozzle that is connected to a pressure liquid source through a pipe. The pressure liquid source includes a liquid storage tank and a liquid supply pump, for example. The liquid storage tank and the liquid supply pump
15 need not necessarily included in the solid polymer separator according to one aspect of the present invention.

[0035]

In the solid polymer separator according to one aspect of the present invention, it is preferable that the drive mechanism be able to adjust the rotational speed of the
20 screen.

[0036]

For example, the rotational speed of the screen may be arbitrarily controlled by arbitrarily adjusting the rotational speed of the drive source of the drive mechanism. When the drive source of the drive mechanism is an electric motor, the rotational speed
25 of the screen may be adjusted by providing an inverter, and controlling the frequency or the like. The rotational speed of the screen may arbitrarily be adjusted corresponding to the size of the tubular screen (e.g., the diameter of a cylindrical screen), the

processing amount (mass per unit time) of the solid polymer (processing target), and the water content in the crumbs at the outlet of the solid polymer separator. The rotational speed of the screen is preferably 5 to 35 rpm, and more preferably 12 to 28 rpm.

[0037]

5 It is preferable that the solid polymer separator according to one aspect of the present invention include a drain plate between the screen and the casing. The drain plate prevents a situation in which a foreign object enters the screen system from the outside. The drain plate is preferably provided between the drive area of the casing (i.e., the space where the roller of the inlet side is positioned) and the area where
10 separated boiling water flows so that the outer side (i.e., the space where the roller is positioned) is separated from the inner side (i.e., the area where the separated boiling water flows). The drain plate is also preferably provided between the drive area of the casing (i.e., the space where the roller of the outlet side is positioned) and the area
15 where separated boiling water flows so that the outer side (i.e., the space where the roller is positioned) is separated from the inner side (i.e., the area where the separated boiling water flows). The foreign object may be waste from the roller, for example. The roller forms a drive power transfer mechanism.

[0038]

 The solid polymer separator according to one aspect of the present invention
20 may suitably be used when the solid polymer is a polymer selected from the group consisting of a butadiene rubber, an isoprene rubber, a styrene-butadiene rubber, a styrene-isoprene rubber, an ethylene- α -olefin copolymer rubber, an ethylene- α -olefin-nonconjugated diene copolymer rubber, a butyl rubber, a styrene-butadiene-styrene block copolymer, a hydrogenated styrene-butadiene-styrene
25 block copolymer, a butadiene resin, and an acrylic resin.

[0039]

 According to another aspect of the present invention, there is provided a method

for separating a solid polymer including separating a solid polymer dispersed in a liquid from the liquid using the solid polymer separator.

[0040]

According to another aspect of the present invention, there is provided a method
5 for producing a rubber material including: a polymerization step that polymerizes a monomer mixed with a solvent to obtain a polymer; a solvent removal step that removes the solvent from the polymer by applying steam; a separation step that separates the polymer from which the solvent has been removed, from boiling water produced due to liquefaction of the steam using the solid polymer separator; a dehydration/drying step
10 that removes water from the polymer that has been separated from the boiling water; and a molding step that molds the polymer from which water has been removed into a given shape.

[0041]

The solid polymer separator according to one aspect of the present invention
15 includes the tubular screen in which a number of slits are formed, the drive mechanism that rotates the screen, and the guide plate that is provided along the inner circumferential surface of the screen. Therefore, when a solid polymer dispersed in a liquid is continuously supplied through one opening (inlet) of the tubular screen, the liquid (e.g., boiling water) passes through the slits, and is discharged to the outside of
20 the system through the outlet provided on the lower side of the casing. On the other hand, the solid polymer (e.g., crumbs) is separated from the liquid, remains on the inner circumferential surface of the tubular screen, and is discharged through the other opening (outlet) of the screen in a constant amount while being guided by the guide plate. The first liquid spray mechanism and the second liquid spray mechanism
25 prevent adhesion and aggregation of the solid polymer on the outer circumferential surface and the inner circumferential surface of the screen. The first liquid spray mechanism and the second liquid spray mechanism can also remove the solid polymer

that adheres to the screen from the screen. This makes it possible to prevent a situation in which the slits of the screen are clogged. Therefore, a decrease in liquid (e.g., boiling water) separation effect does not occur since a decrease in effective filtration area does not occur. This makes it possible to advantageously separate a solid polymer dispersed in a liquid from the liquid. It is also possible to prevent a situation in which a large amount of water (liquid (e.g., boiling water)) remains in the solid polymer (e.g., crumbs), or the resulting block rubber material (intermediate product) has a high water content.

[0042]

In the solid polymer separator according to one aspect of the present invention, the screen to which the solid polymer is supplied is merely rotated. When the screen is being rotated, the solid polymer merely moves from the inlet to the outlet of the screen while being guided by the guide plate. Specifically, a metal contact (metal touch) does not occur in an area of the solid polymer separator (screen) in which the crumbs or the liquid comes in direct contact with the solid polymer separator (screen). Note that a metal contact (metal touch) occurs when the screen drive mechanism includes a sprocket that is connected to an electric motor, and a chain that is fitted around the drive tube, for example. However, the space where the drive mechanism is positioned is separated from the space where the crumbs and the liquid are positioned via a drain plate or the like. Therefore, a situation in which a metal is mixed into the processed solid polymer (e.g., crumbs) does not occur. Therefore, the final product (e.g., block rubber material (intermediate product)) does not contain a metal.

[0043]

The solid polymer separator according to one aspect of the present invention does not include parts (e.g., chain) that require adjustment or replacement. This makes it unnecessary to perform adjustment or replacement work. Therefore, it is possible to continue a production process for a long time, and improve the production efficiency of

the product (e.g., block rubber material (intermediate product)).

[0044]

The solid polymer separator according to one aspect of the present invention is configured so that the first liquid spray mechanism and the second liquid spray
5 mechanism prevent adhesion and aggregation of the solid polymer on the outer circumferential surface and the inner circumferential surface of the screen. The solid polymer separator according to one aspect of the present invention preferably further includes the third liquid spray mechanism and the fourth liquid spray mechanism. The third liquid spray mechanism and the fourth liquid spray mechanism prevent adhesion
10 of the solid polymer to the inner side (top side, side surface, and bottom) of the casing. Each liquid spray mechanism can continuously spray a liquid during the separation process. It is unnecessary to (frequently) perform cleaning work, adjustment work, replacement work, and the like as a result of preventing adhesion of the solid polymer to the screen, and preventing aggregation of the solid polymer. This makes it possible to
15 continue a production process for a long time, and improve the production efficiency of the product (e.g., block rubber material (intermediate product)).

[0045]

The solid polymer separator according to one aspect of the present invention preferably further includes the fifth liquid spray mechanism that is provided on the
20 outlet side of the tubular screen, and sprays a liquid to the inner circumferential surface of the extension tube in the downward direction. Therefore, a liquid (e.g., cold water) can be sprayed directly to the solid polymer. This makes it possible to adjust the temperature of the crumbs transferred to the subsequent dehydration/drying step.

[0046]

25 The solid polymer separator according to one aspect of the present invention is configured so that the solid polymer separated from the liquid is transferred to the subsequent step while being guided by the guide plate. The solid polymer that has

adhered to the inner side (top side, side surface, or bottom) of the screen or the casing, and removed by the first to fourth liquid spray mechanisms falls, and is discharged through the outlet that is provided on the lower side of the casing together with the liquid. The liquid and the solid polymer thus discharged are collected after separation, and supplied to the solid polymer separator. The solid polymer can thus be separated again from the liquid using the solid polymer separator according to one aspect of the present invention. Therefore, the solid polymer can be collected in its entirety (i.e., the solid polymer is not discharged to the outside the system). This makes it possible to improve the production efficiency of the product (e.g., block rubber material (intermediate product)). Moreover, the liquid in which the solid polymer has been dispersed can also be recycled as a liquid sprayed from the first to fourth liquid spray mechanisms. The solid polymer separator according to one aspect of the present invention can thus reduce the amount of waste and environmental impact.

BRIEF DESCRIPTION OF DRAWINGS

[0047]

FIG. 1A is a perspective front view schematically illustrating a solid polymer separator according to one embodiment of the present invention.

FIG. 1B is a perspective plan view (top view) schematically illustrating a solid polymer separator according to one embodiment of the present invention.

FIG. 1C is a perspective left side view schematically illustrating a solid polymer separator according to one embodiment of the present invention.

FIG. 1D is a perspective right side view schematically illustrating a solid polymer separator according to one embodiment of the present invention.

FIG. 2A is a view schematically illustrating a solid polymer separator according to one embodiment of the present invention (i.e., a front view illustrating a cylindrical screen as well as an extension tube and a drive tube connected to the cylindrical screen).

FIG. 2B is a view schematically illustrating a solid polymer separator according to one embodiment of the present invention (i.e., a right side view illustrating only a cylindrical screen).

FIG. 2C is a view schematically illustrating a solid polymer separator according to one embodiment of the present invention (i.e., an oblique view illustrating a cylindrical screen and an extension tube).

FIG. 3 is a view schematically illustrating a solid polymer separator according to one embodiment of the present invention (i.e., a partial perspective front view illustrating only an area around the left end).

FIG. 4 is a view schematically illustrating a solid polymer separator according to one embodiment of the present invention (i.e., a left side view illustrating a drive mechanism).

FIG. 5A is a view schematically illustrating a solid polymer separator according to one embodiment of the present invention (i.e., a view illustrating the bottom of a casing).

FIG. 5B is a view illustrating a related-art solid polymer separator (i.e., a view corresponding to FIG. 5A)).

FIG. 6A is a view schematically illustrating a solid polymer separator according to one embodiment of the present invention (i.e., a view illustrating an access hole provided in a slope of the top side of a casing).

FIG. 6B is a view illustrating a related-art solid polymer separator (i.e., a view corresponding to FIG. 6A)).

DESCRIPTION OF EMBODIMENTS

[0048]

Exemplary embodiments of the present invention are described below with reference to the drawings. Note that the present invention is not limited to the

following exemplary embodiments. Various alterations, modifications, and improvements may be made of the following exemplary embodiments without departing from the scope of the present invention based on the knowledge of a person having ordinary skill in the art. Although the drawings illustrate preferred

5 embodiments of the present invention, the present invention is not limited to the embodiments or information illustrated in the drawings. The present invention may be practised or verified by applying means similar or equivalent to the means described herein, but it is preferable to apply the means described herein. Note that FIGS. 1A to 1D are perspective views wherein the inside of the solid polymer separator is also
10 drawn by a solid line. FIG. 3 is a perspective view wherein the inside of the solid polymer separator is also drawn by a solid line. The position of each element of the solid polymer separator according to one embodiment of the present invention is intended to be determined taking account of all of the drawings.

[0049]

15 The configuration of the solid polymer separator according to one embodiment of the present invention is described below. A solid polymer separator 1 illustrated in FIGS. 1A to 4, 5A, and 6A can separate crumbs (solid polymer) dispersed in boiling water (liquid) from the boiling water.

[0050]

20 The solid polymer separator 1 includes a screen 11, a drive mechanism 12, an extension tube 13, a guide plate 15, a liquid spray mechanism 16 (first liquid spray mechanism), a liquid spray mechanism 17 (second liquid spray mechanism), a liquid spray mechanism 21 (third liquid spray mechanism), a liquid spray mechanism 22 (fourth liquid spray mechanism), a liquid spray mechanism 23 (fifth liquid spray
25 mechanism), and a casing 18.

[0051]

 The screen 11 has a cylindrical shape, and has a circumferential surface that is

formed by regularly arranging a plurality of wires 111 (preferably) having a triangular cross-sectional shape in parallel to the axial direction of the cylindrical screen 11 (see FIGS. 2A to 2C). A number of slits 112 that allow boiling water to pass through are formed by the plurality of wires 111. The width (aperture size) of each slit 112 is
5 (preferably) 1.5 to 2.5 mm.

[0052]

The drive mechanism 12 is a means that rotates the screen 11 in a circumferential direction S (see FIGS. 2B and 2C). The drive mechanism 12 includes an electric motor 121, a sprocket 141 that is connected to the electric motor 121, a drive
10 tube 123 that is connected to the inlet side (i.e., the left side in FIGS. 1A and 2A) of the screen 11, a chain 142 that is fitted around the circumferential surface of the drive tube 123, and four rollers 122 that are provided to come in contact with the drive tube 123 (see FIG. 4). The sprocket 141 that is connected to the electric motor 121 engages the chain 142. The sprocket 141 that is secured on the electric motor 121 is rotated by
15 driving the electric motor 121 to rotate the chain 142 that engages the sprocket 141, the drive tube 123, and the screen 11 that is connected to the drive tube 123. The four rollers 122 support the drive tube 123, the screen 11, and the extension tube 13 so that the drive tube 123, the screen 11, and the extension tube 13 rotate smoothly. A circuit included in the electric motor 121 is provided with an inverter, for example, so that the
20 rotational speed of the electric motor 121 can be adjusted (changed). Specifically, the rotational speed of the screen 11 can (preferably) be adjusted to 12 to 28 rpm.

[0053]

The extension tube 13 is connected to the outlet side of the cylindrical screen 11. The extension tube 13 has a cylindrical shape, and has the same diameter as that of the
25 screen 11. Note that the extension tube 13 is not a screen formed by arranging a plurality of wires, but is formed by a cylindrical metal plate.

[0054]

The guide plate 15 having a spiral shape is provided along the inner circumferential surface of the screen 11 and the extension tube 13 that is connected to the screen 11 continuously from the inlet side of the screen 11 to the extension tube 13, for example (see FIGS. 2A to 2C). The guide plate 15 having a spiral shape thus forms a groove 151 along the inner circumferential surface of the screen 11 and the extension tube 13. The number of threads of the guide plate 15 having a spiral shape is (preferably) 4 to 8. The height H of the guide plate 15 is (preferably) 5 to 15 cm. The guide plate 15 is preferably provided perpendicularly to the screen (see FIGS. 2B and 2C).

[0055]

The casing 18 encloses the screen 11, the drive mechanism 12, the extension tube 13, the guide plate 15, the liquid spray mechanism 16, the liquid spray mechanism 17, the liquid spray mechanism 21, the liquid spray mechanism 22, and the liquid spray mechanism 23. The casing 18 has an access hole 181 (upper side) and an outlet 182 (lower side) (see FIGS. 1A to 1D). The liquid spray mechanism 21 and the liquid spray mechanism 22 are secured on the inner side of the casing 18. The top side of the casing 18 is formed to have a trapezoidal cross-sectional shape. The access hole 181 is formed in the slope of the top side of the casing 18 (see FIGS. 1C and 1D). The bottom of the casing 18 is tilted, and tapered. The outlet 182 is provided at the end of the bottom of the casing 18 (see FIG. 1A).

[0056]

The access hole 181 is formed so that the inner side (i.e., the top side that is formed to have a trapezoidal cross-sectional shape) of the casing 18 is flat (see FIG. 6A). Therefore, adhesion and aggregation of crumbs can be advantageously prevented by a sprayed liquid 61 emitted from a spray nozzle 213 (described later). In a related-art example illustrated in FIG. 6B, an access hole 62 is formed so that the access hole 62 is depressed in the inner side of the casing. In this case, the sprayed liquid 61 may not be

uniformly emitted to the inner side of the casing (i.e., may not be spread over the entire inner side of the casing), and a crumb 63 that adheres to the inner side of the casing may not be removed. However, such a situation does not occur by forming the access hole 181 in the casing 18 as described above.

5 [0057]

A drain plate 131 is provided between the space where the roller 122 is positioned and the area where separated boiling water flows on the inlet side of the casing 18 (i.e., at a position where the drive tube 123 is disposed), and between the area where separated boiling water flows and the space where the roller 122 is positioned on the outlet side of the casing 18 (i.e., at a position where the extension tube 13 is disposed) so that the outer side (i.e., the space where the roller 122 is positioned) is separated from the inner side (i.e., the area where the separated boiling water flows) (see FIGS. 3 and 4). The drain plate 131 prevents a situation in which a foreign object enters the system (i.e., the area of the casing 18 where water flows) from the outside.

15 [0058]

The liquid spray mechanism 16 includes a pipe 162 that is connected to a liquid source (not illustrated in the drawings), and a spray nozzle 161 that is provided to the pipe 162. Two pipes 162 are provided obliquely above the screen 11 (i.e., the outer circumferential surface of the screen 11) (see FIGS. 1B to 1D), and (preferably) 8 to 14 spray nozzles 161 are provided to each pipe 162. The spray nozzle 161 mainly sprays a liquid to the outer circumferential surface of the screen 11.

[0059]

The liquid spray mechanism 17 includes a pipe 172 that is connected to a liquid source (not illustrated in the drawings), and a spray nozzle 171 that is provided to the end of the pipe 172 (see FIGS. 1A and 1D). The pipe 172 is disposed to extend downward to the center of the plane (circle) that is perpendicular to the axial direction of the cylindrical screen 11 (extension tube 13) in the vicinity of the extension tube 13

(screen 11). Two spray nozzles 171 are provided at the end of the pipe 172, for example. The spray nozzles 171 spray a liquid to the inner circumferential surface of the screen 11 in the upward direction.

[0060]

5 The liquid spray mechanism 21 includes a pipe 212 that is connected to a liquid source (not illustrated in the drawings), a spray nozzle 211 that is provided to the end of the pipe 212, and a spray nozzle 213 (see FIGS. 1A to 1D). Four spray nozzles 211 are provided at approximately the center of the top side of the casing 18 so that the four spray nozzles 211 spray a liquid in a different direction, for example. The four spray
10 nozzles 211 respectively spray a liquid to the four side surfaces of the casing 18. Two spray nozzles 213 are provided to the top side of the casing 18, for example. Each spray nozzle 213 discharges a liquid so as to wash (clean) the side surface of the casing 18 that is parallel to the screen and tends to allow adhesion of the crumbs.

[0061]

15 The liquid spray mechanism 22 includes a pipe 222 that is connected to a liquid source (not illustrated in the drawings), and a spray nozzle 221 that is provided to the end of the pipe 222 (see FIGS. 1A, 1B, and 5A). Four spray nozzles 221 are provided at the bottom of the casing 18 at the corner on the outlet side (on the side of the extension tube 13), for example. The spray nozzles 221 respectively spray a liquid to
20 the lower side surface and the bottom of the casing 18. The four spray nozzles 221 of the liquid spray mechanism 22 are positioned so that the spray position differs for each nozzle. This makes it possible to prevent collision/interference of the sprayed liquid 51, and prevent adhesion and aggregation of the crumbs by efficiently spraying a liquid to the bottom and the lower side surface of the casing. In FIG. 5B, four spray nozzles
25 52 have an identical spray position. Therefore, sprayed liquids 51 collide and interfere each other. Since the boiling water is separated from the crumbs on one side of the screen 11 (i.e., on the side on which the screen 11 is rotated), the boiling water tends to

flow on one side of the screen 11. Therefore, an uneven flow occurs at the bottom of the casing, and the crumbs that have passed through the screen, and crumbs 53 removed from the wall tend to accumulate in an area in which the flow rate is low. It is possible to prevent such a problem by employing the liquid spray mechanism 22 that can prevent liquid interference as a result of adjusting the liquid spray position.

[0062]

The liquid spray mechanism 23 is disposed at a position approximately the same as that of the liquid spray mechanism 17. The liquid spray mechanism 23 includes a pipe 232 that is connected to a liquid source (not illustrated in the drawings), and a spray nozzle 231 that is provided to the end of the pipe 232 (see FIGS. 1A and 1D). The pipe 232 is disposed to extend downward to the center of the plane (circle) that is perpendicular to the axial direction of the cylindrical screen 11 (extension tube 13) in the vicinity of the extension tube 13 (screen 11). One spray nozzle 231 is provided at the end of the pipe 232, for example. The spray nozzle 231 sprays a liquid to the inner circumferential surface of the extension tube 13 in the downward direction.

[0063]

A method for producing a solid polymer separator according to one embodiment of the present invention is described below taking the solid polymer separator 1 as an example.

[0064]

The solid polymer separator 1 may be obtained by processing/assembling commercially available materials/sheet metals. It is preferable that the the screen 11 (wire 111 and securing member), the drive tube 123 of the drive mechanism 12, the extension tube 13, the guide plate 15, the pipes and the spray nozzles of the liquid spray mechanisms 16, 17, 21, 22, and 23, and the casing 18 (including the drain plate) be formed of stainless steel. Specific examples of the stainless steel include JIS SUS304, JIS SUS316, and the like. It is preferable to use low-carbon stainless steel. It is

preferable that the roller of the drive mechanism 12 be formed of a high-strength resin material (engineering plastic). Specific examples of the high-strength resin material include MC nylon (registered trademark) (polyamide resin).

[0065]

5 A method for producing a rubber material according to one embodiment of the present invention is described below taking an example of producing a butadiene rubber. A method for separating a solid polymer according to one embodiment of the present invention is also described below taking an example of separating a solid polymer using the solid polymer separator 1.

10 [0066]

 A butadiene monomer (1,3-butadiene) is provided. The butadiene monomer is normally produced (as a by-product) by cracking naphtha derived from crude oil, or produced from ethylene. The butadiene monomer is mixed with a solvent (e.g., dehydrated and purified toluene, benzene, or xylene). After the addition of a catalyst

15 (e.g., nickel catalyst, titanium catalyst, cobalt catalyst, neodymium catalyst, or lithium catalyst), the butadiene monomer is polymerized to obtain a butadiene polymer. After the addition of a polymerization terminator (e.g., methanol) and an optional aging preventive, the solvent is removed by applying steam at 105 to 200°C.

[0067]

20 The butadiene polymer is dispersed in boiling water derived from steam in the form of crumbs (small masses). Therefore, the butadiene polymer is separated from the boiling water using the solid polymer separator 1. Specifically, the screen 11 of the solid polymer separator 1 is rotated in the circumferential direction of the screen 11 that corresponds to the spiral direction of the guide plate 15, and the butadiene polymer

25 dispersed in the boiling water is continuously supplied to the solid polymer separator 1 through the inlet of the screen 11 (i.e., on the side of the drive tube 123). The boiling water passes through the slits 112, and is discharged from the outlet 182 of the casing 18,

while the butadiene polymer is separated from the boiling water, remains on the inner circumferential surface of the screen 11, and is transferred to the subsequent process from the outlet of the screen 11 (i.e., on the side of the extension tube 13) in a constant amount while being guided by the guide plate 15 having a spiral shape.

5 [0068]

The butadiene polymer is then dehydrated using a dehydration unit, dried using a dryer, molded into a given block shape using a press molding unit or the like, and optionally lapped to obtain a rubber material (intermediate product).

10 INDUSTRIAL APPLICABILITY

[0069]

The solid polymer separator according to the embodiments of the present invention may suitably be used as a means for separating a solid polymer dispersed in a liquid from the liquid when producing various rubber products.

15

REFERENCE SIGNS LIST

[0070]

1: solid polymer separator, 11: screen, 12: drive mechanism, 13: extension tube, 15: (spiral) guide plate, 16: liquid spray mechanism, 17: liquid spray mechanism, 18: casing,
20 21: liquid spray mechanism, 22: liquid spray mechanism, 23: liquid spray mechanism, 51: sprayed liquid, 52: spray nozzle, 53: crumb, 61: sprayed liquid, 62: access hole, 63: crumb, 111: wire, 112: slit, 121: electric motor, 122: roller, 123: drive tube, 131: drain plate, 141: sprocket, 142: chain, 151: groove, 161: spray nozzle, 162: pipe, 171: spray nozzle, 172: pipe, 181: access hole, 182: outlet, 211: spray nozzle, 212: pipe, 213: spray
25 nozzle, 221: spray nozzle, 222: pipe, 231: spray nozzle, 232: pipe

CLAIMS

1. A solid polymer separator that separates a solid polymer dispersed in a liquid from the liquid, the solid polymer separator comprising:
 - 5 a tubular screen in which a number of slits are formed;
 - a drive mechanism that rotates the screen;
 - a guide plate that is provided along an inner circumferential surface of the screen;
 - a first liquid spray mechanism that is provided over an outer circumferential
 - 10 surface of the screen, and sprays a liquid to the outer circumferential surface of the screen; and
 - a casing that encloses at least the screen, and has an outlet that is provided on a lower side.
- 15 2. The solid polymer separator according to claim 1, further comprising:
 - a second liquid spray mechanism that is provided on an outlet side of the tubular screen, and sprays a liquid to the inner circumferential surface of the screen in an upward direction.
- 20 3. The solid polymer separator according to claim 1 or 2, further comprising:
 - a third liquid spray mechanism that is provided in an upper area of the casing, and sprays a liquid to an inner side of the casing.
4. The solid polymer separator according to any one of claims 1 to 3, further
- 25 comprising:
 - a fourth liquid spray mechanism that is provided in a lower area of the casing, and sprays a liquid to an inner side of the casing.

5. The solid polymer separator according to any one of claims 1 to 4, further comprising:

an extension tube that is connected to an outlet side of the tubular screen; and

5 a fifth liquid spray mechanism that is provided on the outlet side of the tubular screen, and sprays a liquid to an inner circumferential surface of the extension tube in a downward direction.

6. The solid polymer separator according to any one of claims 1 to 5,

10 wherein the drive mechanism can adjust a rotational speed of the screen.

7. The solid polymer separator according to any one of claims 1 to 6, further comprising:

a drain plate that is provided between the screen and the casing, and prevents

15 entrance of a foreign object into a system including the screen from outside the system.

8. The solid polymer separator according to any one of claims 1 to 7,

wherein the solid polymer is a polymer selected from a group consisting of a

butadiene rubber, an isoprene rubber, a styrene-butadiene rubber, a styrene-isoprene

20 rubber, an ethylene- α -olefin copolymer rubber, an ethylene- α -olefin-nonconjugated

diene copolymer rubber, a butyl rubber, a styrene-butadiene-styrene block copolymer, a

hydrogenated styrene-butadiene-styrene block copolymer, a butadiene resin, and an

acrylic resin.

25 9. A method for separating a solid polymer comprising separating a solid polymer dispersed in a liquid from the liquid using the solid polymer separator according to any one of claims 1 to 8.

10. A method for producing a rubber material comprising:
- a polymerization step that polymerizes a monomer mixed with a solvent to obtain a polymer;
 - 5 a solvent removal step that removes the solvent from the polymer by applying steam;
 - a separation step that separates the polymer from which the solvent has been removed, from boiling water produced due to liquefaction of the steam using the solid polymer separator according to any one of claims 1 to 8;
 - 10 a dehydration/drying step that removes water from the polymer that has been separated from the boiling water; and
 - a molding step that molds the polymer from which water has been removed into a given shape.