SPECIFICATION

Batch type grinding and dispersing apparatus

FIELD OF THE INVENTION

The present invention relates to a grinding and dispersing apparatus, by which solid particles in a solid/liquid-type treatment material used in various fields such as chemistry, medicines, electronics, foods, feed or the like, are finely ground by stirring them together with grinding media (beads) and dispersed in a liquid and, more particularly, to a batch type grinding and dispersing apparatus in which grinding media are contained in a vessel, the vessel is immersed in a treatment material in a tank, and the treatment material is circulated through the vessel to conduct a batch type grinding and dispersion treatment.

BACKGROUND INFORMATION

Batch type grinding and dispersing apparatus is an apparatus by which a grinding and dispersing treatment is carried out in a concentrated manner using a small amount of grinding media, and for example, an apparatus described in JP-A-(H)11-244679 has been known. This publication also describes a grinding and dispersing apparatus in which a vessel containing the grinding media is a container having an opening

at its upper portion and a screen at its bottom portion. Further, an apparatus in which the vessel is formed in a basket shape having a screen on its entire surface has also been known. With such a vessel, if the aperture area of the screen is made small, the circulation flow rate of the material to be treated is reduced and problems of clogging may sometimes be caused. If the aperture area of the screen is made large, the grinding media may flow out, by which small-diameter grinding media cannot be used. In addition, abrasion of the screen by the grinding media is increased and degradation of abrasion resistance is caused.

With the batch type grinding and dispersing apparatus, since the material to be treated is stirred together with the grinding media, pin-type stirring blades are usually disposed in the vessel. Further, a structure is also known in which the material to be treated is fed to the vessel by stirring blades for feeding disposed inside the tank or at the opening portion of the vessel. However, only by rotating the stirring blades for feeding, the flow rate of the material to be treated flowing into the vessel is hardly increased. Accordingly, with conventional batch type grinding and dispersing apparatuses, the number of passing times of the material to be treated passing through the vessel is small, distribution of resident time of the material to be treated in the vessel tends to be broad.

According to Rittinger's theory, it has been known that in the dispersion with a beads mill (grinding and dispersing apparatus), if the distribution of resident time of the material to be treated in the beads mill is sharp, the particle size distribution of finely ground particles obtained by dispersion is sharp. However, as mentioned above, in conventional batch type grinding and dispersing apparatuses, since the distribution of resident time tends to be broad, particles with sharp particle size distribution are hardly obtainable.

Further, as also mentioned above, in conventional batch type grinding and dispersing apparatuses, as the stirring blades disposed in the vessel, pin-type stirring blades which extend radially outwardly from a rotational shaft are often used. However, with such pin-type stirring blades, the shear rate at the front end portion of blade is inferior to that of a disc blade, and particles can hardly be finely ground with high efficiency. Further, a batch type grinding and dispersing apparatus has also been known in which as the screen of vessel, a stay bolt extending downwardly is disposed at the periphery of the vessel, and a plurality of plates are layered at intervals on the stay bolt or wire is wound around it at intervals to form a screen. However, in such a structure, when the screen is cleaned, the stay bolt becomes an obstruction, whereby

stagnation of the material to be treated will happen at the stay bolt portion and the cleaning can hardly be conducted, resulting in problems in cleaning properties.

SUMMARY OF THE INVENTION

Embodiments of the present invention increase the flow rate of a material to be treated flowing in a the vessel in a batch type grinding and dispersing apparatus in which a material to be treated is contained in a vessel, the vessel is immersed in a treatment liquid in a tank, and the material to be treated is circulated in the tank and vessel to conduct a grinding and dispersion treatment. Thus, it becomes possible to realize a batch type grinding and dispersing apparatus, in which the number of times of circulation of the material to be treated circulating within the vessel is increased, by which the distribution of resident time is made sharp and it becomes possible to produce finely ground particles with a sharp particle size distribution.

Further, embodiments of the present invention provide a batch type grinding and dispersing apparatus in which cleaning can be made easily and clogging is hardly caused.

According to an aspect of the present invention, there is provided a batch type grinding and dispersing apparatus in which a vessel containing grinding media is immersed in a treatment liquid in a tank and subjected to a grinding and

dispersion treatment, which includes: a vessel having an opening portion which opens at the upper side of the vessel; a tubular screen which is formed below the opening portion and through which the grinding media are not allowed to pass, and a bottom plate which covers the bottom portion of the screen and has no flow aperture; a rotational shaft which extends into the vessel through the opening portion; and plural disc blades each of which is connected to the rotational shaft of the vessel and has a through hole; wherein the plural disc blades are disposed closely adjacent to each other so that when the rotational shaft rotates, the plural disc blades generate a pumping action by disc flow and suck the material to be treated into the vessel, and at the same time, form a side flow of the material to be treated and discharge the material to be treated out of the periphery of the disc blades, within the tank, plural stirring blades for axial flow are disposed to generate an axial flow in the tank so that the material to be treated in the tank flows in the tank is flowed upward or downward, and wherein the stirring blades for axial flow are paddle stirring blades, at least one of which forms a down-flow to stir down the material to be treated in the tank and at least one other of which forms an up-flow to stir up the material to be treated in the tank.

Further, according to an embodiment the present invention, in the above batch type grinding and dispersing apparatus, the screen and the bottom plate are integrally connected, and within

the tank, plural stirring blades for axial flow are disposed so that the material to be treated in the tank flows in the tank with axial flow thereby generated.

An embodiment of the present invention is constituted as mentioned above and the plural disc blades are disposed in the vessel closely adjacent to each other to generate a pumping action by disc flow, and therefore when the disc blades rotate by the rotational shaft, a sucking action of positively sucking the material to be treated from the opening portion of the vessel towards the inside of the vessel. The material to be treated that passes through the through holes of the upper disc blade and reaches the lower disc blade, flows radially in the form of a radial flow along the plane surface of the disc blade and is discharged out of the tank through the peripheral screen. During this operation, the material to be treated is stirred with the grinding media, and therefore fine grinding by the grinding and dispersion proceeds. The material to be treated discharged into the tank is positively sucked into the vessel again by the pumping action and subjected to the grinding and dispersion treatment. The material to be treated is positively sucked into the vessel by the pumping action generated in the vessel, and then discharged from the vessel, and therefore the flow rate of the material to be treated which flows into and is discharged from the vessel can be increased. As the results, the number of times of circulation of the material to be treated

passing through the vessel can be increased, the distribution of resident time can be made sharp, and fine particles with a sharp particle size distribution can be obtained.

Further, if plural stirring blades for axial flow which is capable of generating axial flow are disposed in the tank, the flow of the material to be treated in the tank can be controlled to form a downward flow or an entire flow. By the axial flow, it is possible to increase the flow rate of the material to be treated which is sucked into the vessel through the opening portion of the vessel and the above effects by the increased flow rate can be further enhanced. Here, if the plural stirring blades for axial flow are paddle blades which generate a laminar flow one of which becomes a stirring-down flow (downward flow) and another one becomes a stirring-up flow (upward flow), entire flow in the tank can be realized, the number of times of circulation of the material to be treated passing through the vessel can further be increased, the distribution of resident time can be made sharp, the grinding and dispersing time can be shortened, and a sharp particle size distribution can be obtained. Further, by using the disc blades, the shear rate at the front end portion of the blade becomes 1.5 times or more as compared with the pin-type blade, by which the dispersion effects can be improved. If the screen and the bottom plate are integrally connected, obstacles that will form stagnation in the flow of the material to be treated will not

be present around the vessel at the time of cleaning, and the cleaning properties can be enhanced.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 shows an example of the present invention and is a side view taken partly in cross-section.

Fig.2 shows an example in which three disc blades are combined and is a side view taken partly in cross-section.

Fig.3 shows an example in which three disc blades are combined and is a plane view taken partly in cross-section.

Fig.4 is a plane view showing a gap member.

Fig.5 shows an example of a combination of disc blades, Fig.5A is a cross-sectional view, Fig.5B is a plane view showing an upper disc blade in Fig.5A; Fig.5C is a plane view showing a middle disc blade in Fig.5A; and Fig.5D is a plane view showing a lower disc blade in Fig.5A.

Fig.6 shows an example of another combination of disc blades, Fig.6A is a cross-sectional view, Fig.6B is a plane view showing an upper disc blade in Fig.6A; Fig.6C is a plane view showing a middle disc blade in Fig.6A; and Fig.6D is a plane view showing a lower disc blade in Fig.6A.

Fig.7 shows an example of a still another combination of

disc blades, Fig.7A is a cross-sectional view, Fig.7B is a plane view showing an upper disc blade in Fig.7A; Fig.7C is a plane view showing a middle disc blade in Fig.7A; and Fig.7D is a plane view showing a lower disc blade in Fig.7A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig.1 shows an example of a batch type grinding and dispersing apparatus of the present invention, in which, above a main body 1, is disposed a frame 4 which moves upward and downward along a guide shaft 3 by an elevating shaft 2. Below the frame 4, a tank 5 containing a material to be treated is transported and held at a fixed position by a holder 6. Around the tank 5, a tank jacket 7 through which a temperature-controlling fluid such as cooling water flows is disposed.

In the tank 5, a vessel 8 containing grinding media (beads) of glass, zircon, zirconia, stainless steel, ceramics or the like, preferably containing high density grinding media (not shown) is placed. The vessel 8 has, at its upper portion, an upper jacket 9 through which a temperature-controlling fluid such as cooling water flows, and is disposed below the frame 4 by a stay 10 for a fluid passage which also functions as a flow path of the temperature-controlling fluid. At the upper portion of the vessel 8, is disposed a partition wall 11 which

declines towards the inner portion of the vessel through the jacket 9, and at its center portion, an opening portion 12 is formed.

Below the upper jacket 9 of the vessel 8, a tubular screen 13 is detachably connected thereto, and the tubular screen 13 has flow apertures such as pores, slits or mesh, the size of which will not allow the grinding media contained in the vessel to pass therethrough, but will allow the material to be treated to pass therethrough. The bottom portion of the tubular screen 13 is covered with a bottom plate 14 having no flow aperture. The bottom plate 14 and the screen 13 are integrally connected by disposing an appropriate connecting portion (not shown) such as a flange and fastening it with a fixing means such as a bolt or rivet. As the screen, it is preferred to prepare plural different screens each having an appropriate flow aperture size so that the screen can be replaced with another one having different flow aperture size depending on the grinding media. Here, on the bottom plate, a takeaway port (not shown) through which the grinding media are brought in and taken out may be disposed.

Into the vessel 8, a rotational shaft 15 extending into the vessel through the opening portion 12 is inserted. The rotational shaft 15 extends vertically and downwardly from the

frame 4 and driven by a driving motor 16 disposed on the frame 4, and plural disc blades 17 are disposed at the lower end thereof. In the examples, three disc blades 17 are combined, but two or four or more disc blades may be combined. The plural disc blades are constituted by disc blades each having a through hole 18 formed in an appropriate size at an appropriate portion, or disc blades having no through hole. The plural disc blades 17 are disposed closely adjacent to each other so that they can generate a pumping action by disc flow when they are rotated. The pumping action by disc flow is a pumping action as explained with reference to the examples. Namely, when the disc blades 17 rotate, the material to be treated is sucked into the vessel through the opening portion 12, the material to be treated sucked into the vessel flows in the axial direction through the through hole 18, and then becomes a radial flow flowing in the radius direction of the disc blade, and is discharged towards the outer periphery of the disc blades along the plane surface of the disc blade. By this pumping action, the material to be treated which has passed through the flow aperture of the screen returns to the inside of the tank. As mentioned above, the pumping action which generates the suck and discharge actions by the plural disc blades disposed closely adjacent to each other has been known as a conventional rotary disc type pump

in which a fluid is discharged in a radial direction of the disc blades by utilizing the friction force or centrifugal force of the fluid which is placed in contact with the surface of the disc blade, and at the same time, the fluid is sucked. Accordingly, if the distance between the disc blades 17 is too broad, no pumping action is generated, and therefore the plural disc blades 17 are held in such a state that these are disposed with a narrow distance in closely adjacent to each other by sandwiching a gap member 19 therebetween.

As illustrated in Fig.3 and Fig.4, the gap member 19 is formed to have a cross-section of substantially rectangular shape and located in the radial direction of the disc blade 17. The gap member 19 is constituted in that an inner end face 20 facing the center of the disc blade is formed to have a narrow width, and among both side faces each connecting to each end point of the inner end face 20, a side face 21 at the side facing the rotation direction of the disc blade is formed straight and a side face 22 at the side opposite to the rotation direction is formed slantwise. By this structure, when the disc blade rotates counterclockwise in Fig.3 and Fig.4, discharge of the material to be treated is accelerated, resulting in increase of discharged amount. At an outer end face 23 of the gap member 19 positioned at the external side in the radial direction, one

of corner portions is formed to have an arc face shape and another one is formed to have an angular shape. At the plane portion of the gap member 19, as illustrated in Fig.2, a convex portion 25 is disposed to engage a concave portion 24 disposed on the disc blade 17. The plural disc blades 17 are stacked with the gap member 19 interposed therebetween, and fastened by a bolt 26.

When the shear rate of the above disc blade 17 is compared with the shear rate between the front end portions of the conventional pin-type blade, the disc blade shows about 1.5 times higher than the pin-type blade, and as the results, the grinding and dispersion treatment can be made fast. The surface of the plane portion of the disc blade 17 may be plane as it is, but pins 27 may be disposed thereon taking the particle size or hardness of the material to be treated into account. More preferably, the pins 27 project at the peripheral portion of the disc blade 17 so that impact force will be applied to the grinding media which tend to gather at the peripheral portion of the disc blade 17 for efficient diffusion. Here, in the example shown in Fig.2, the pins are standing vertically on the upper or lower face of the disc blade, but may project horizontally at the periphery of the disc blade 17 (not shown). Instead of the pins, convex portions or concave portions may

be formed on the plane surface of the disc blade to apply impact force to the grinding media (not shown).

As mentioned above, by rotating the plural disc blades 17 in the vessel, the material to be treated can be sucked into the vessel 8 by a pumping action, but in the example, a feeding (sucking) means is further disposed to positively feed the material to be treated to the vessel. In Fig.1, as the feeding means, a screw 28 is disposed around the rotational shaft 15 located at the opening portion 12 of the vessel 8. When the rotational shaft 15 rotates, the material to be treated is guided by the screw 28 and fed (sucked) to the vessel 8. Here, instead of the screw, a feeding blade such as an axial flow turbine blade or a paddle blade, may be used as the feeding means (not shown).

As mentioned above, the disc blade 17 may have a through hole 18 formed at an appropriate position. Fig.5 to Fig.7 show examples of combination of a disc blade having various through holes or a disc blade having no through hole. The examples illustrated in Fig.5A to Fig.5D have three disc blades. On an upper disc blade 29, as illustrated in Fig.5B, four through holes 31 are formed around an installation portion 30 to be connected to the rotational shaft 15. On a middle disc blade 32, four through holes 33 are formed as made on the upper disc

blade 29. A lower disc blade 34 has no through hole. In this structure, the material to be treated which has been sucked in the axial direction through the opening portion 12 by a pumping action by the disc blades 29, 32 and 34 passes through the through holes of the upper disc blade and the through holes of the middle disc blade and flows in the radial direction of each disc blade, whereas the material to be treated which has reached the lower disc blade flows in the radial direction along the plane face of the lower disc blade.

In a case of the example illustrated in Fig.6A, an upper disc blade 35 and a middle disc blade 36 are provided with large through holes 37, 38 formed around the rotational shaft 15 concentrically with the disc blades. A lower disc blade 39 has an installation portion 30 of the rotational shaft, but has no through hole formed. In this case also, in the substantially similar way to the example illustrated in Fig.5A, the material to be treated flows by being sucked and discharged by a pumping action.

In a case of the example illustrated in Fig.7A, on an upper disc blade 40, an installation portion 30 of the rotational shaft and four through holes 41 are disposed as illustrated in Fig.7B. On a middle disc blade 42 and a lower disc blade 43, large through holes 44, 45 are formed concentrically with the

disc blades. In this case, when the disc blades 40, 42, 43 rotate, the material to be treated fed through the opening portion 12 flows in the radial direction and the material to be treated which has reached a bottom plate 14 of a vessel is sucked through a through hole 45 of the lower disc blade 43, enters the space between the middle disc blade 42 and the lower disc blade 43 and flows in the radial direction along the plane surface of each disc blade.

With reference to Fig.1, between the vessel 8 and the tank 5, a plurality of stirring blades for axial flow 46 such as paddle stirring blades are disposed so that the material to be treated in the tank will flow upward and downward in the form of an axial flow. The stirring blades for axial flow 46 are rotated by a driving motor 48 and a rotational shaft 47 hanging down from the frame 4. In Fig.1, two paddle stirring blades are shown. However, three or more paddle stirring blades may be disposed equally spaced around the vessel. The stirring blades for axial flow 46 can generate an upflow or downflow by the shape or rotation direction of the paddle, and therefore can be appropriately driven depending on the flowing properties of the material to be treated. For example, if all the stirring blades for axial flow 46 are stirring-down paddle stirring blades, a downward laminar flow is formed in the tank, and the flow rate

of the material to be treated flowing into the vessel through the opening portion 12 can be further increased. Further, if one of the stirring blades for axial flow is a stirring-down paddle stirring blade and another one is a stirring-up paddle stirring blade, the flow in the tank is a relative circulating flow and it is possible to obtain the entire flow without stagnation of the material to be treated.

Thus, the grinding media, preferably grinding media of a high density is placed in the vessel 8, and the vessel is submerged under the liquid surface of the tank 5 containing the material to be treated. And, when the driving motors 16, 48 are rotated, the rotational shafts 15, 47 are rotated via a rotation-transmitting mechanism not shown in the figure. By this rotation, the material to be treated in the tank flows towards the opening portion of the vessel and is sent to the inside of the vessel by the screw 28 disposed on the rotational shaft 15. Further, the disc blade 17 in the vessel exhibits a pumping action by rotation, and therefore the material to be treated passes through the opening portion 12 of the vessel 8 and is positively sucked into the vessel. The material to be treated which has entered the vessel is stirred together with the grinding media and dispersed. The dispersed material to be treated is discharged from the vessel 8 to the tank 5 through

the screen 13 by the discharging action of the pumping action by the disc blade 17. The material to be treated discharged from the vessel is sucked into the vessel 8 again through the opening portion 12 by the pumping action by the screw 28 or disc blade 17, and dispersed until it reaches the desired level. At this time, heat generation in the vessel 8 and tank 5 can be cooled by the cooling water passing through the tank jacket 7 and the upper jacket 9 disposed on the vessel 8. Depending on the material to be treated, warm water may be used as a temperature-controlling fluid.

As mentioned above, with the batch type grinding and dispersing apparatus, by rotating the plural disc blades disposed closely adjacent to each other, a pumping action which becomes a disc flow is generated in the vessel, the material to be treated is sucked into the vessel securely and in a large amount, and the number of times of circulation of the material to be treated is increased to make the resident time distribution sharp, by which a grinding and dispersion treatment with a sharp particle size distribution can be conducted.

Claims

1. A batch type grinding and dispersing apparatus in which a vessel containing grinding media is immersed in a treatment liquid in a tank and subjected to a grinding and dispersion treatment, which comprises:

a vessel having an opening portion which opens at the upper side of the vessel;

a tubular screen which is formed below the opening portion and through which the grinding media are not allowed to pass, and a bottom plate which covers the bottom portion of the screen and has no flow aperture;

a rotational shaft which extends into the vessel through the opening portion; and

plural disc blades each of which is connected to the rotational shaft of the vessel and has a through hole;

wherein the plural disc blades are disposed closely adjacent to each other so that when the rotational shaft rotates, the plural disc blades generate a pumping action by disc flow and suck the material to be treated into the vessel, and at the same time, form a side flow of the material to be treated and discharge the material to be treated out of the periphery of the disc blades,

within the tank, plural stirring blades for axial flow are disposed to generate an axial flow in the tank so that the material to be treated in the tank flows in the tank is flowed upward or downward, and

wherein the stirring blades for axial flow are paddle stirring blades, at least one of which forms a down-flow to stir down the material to be treated in the tank and at least one other of which forms an up-flow to stir up the material to be treated in the tank.

2. The batch type grinding and dispersing apparatus according to Claim 1,

wherein the plural disc blades are connected via a gap member located in the radial direction,

wherein the gap member is formed in a generally rectangular shape in cross section, whose inner end surface facing to the center of disk blades is formed narrower, and

wherein among both side surfaces connecting both ends of the inner end surface, one side surface is formed in linear shape, while the other side surface is provided with a slope.

3. The batch type grinding and dispersing apparatus according to Claim 1, wherein pins are disposed on plane portions of the disc blades.

4. The batch type grinding and dispersing apparatus according to Claim 1, wherein the tubular screen and the bottom plate of the vessel are integrally connected.