

Title of the Invention: Medium dispersing apparatus

BACKGROUND OF THE INVENTION

(1) Technical field

The present invention relates to an immersion-type dispersing apparatus wherein a material to be treated (or mill base) containing solid particles and a treating liquid, is finely ground by use of a dispersion medium, and dispersed in a treating liquid. More particularly, it relates to an immersion-type dispersing apparatus wherein the dispersion medium is contained in a dispersion chamber and this dispersion chamber is immersed in the material to be treated for dispersion treatment.

(2) Background art

Various types of immersion-type dispersing apparatuses have been known wherein a dispersion chamber containing a dispersion medium is immersed in a tank and dispersion treatment is conducted by a batch system.

Such dispersing apparatuses are described in, for example, JP-B-59-46665 (JP-A-58-174230), JP-B-62-16687 (JP-A-60-48126), JP-B-5-82253 (JP-A-1-210020), JP-B-6-73620 (JP-A-6-86924) and JP-B-8-17930 (JA-A-3-72932). In these conventional apparatuses, since pins, pegs or the like are used as a means for stirring the dispersion medium in the dispersion chamber, particle size reduction of the solid particles in the material to be treated tend to be insufficient. For example, the dispersed products are sometimes found to be ground to a level of only 10 μ in particle size.

Further, in conventional immersion-type dispersing apparatuses, since a drive shaft passes through a space wherein the dispersion medium moves in the dispersion chamber, the dispersion medium may sometimes clog in a through-hole portion or flow out from the through-hole portion.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an immersion-type type dispersing apparatus of the above structure, having the dispersibility further improved.

Further, it is another object of the present invention to provide an immersion-type dispersing apparatus, by which it is possible to separately control the flow of the material to be treated in a tank and the flow of the dispersion medium in the dispersion chamber, and to prevent the clogging or outflow of the dispersion medium contained in the dispersion chamber.

According to the present invention, it was found that the high dispersibility beyond the conventional immersion-type dispersing apparatus can be accomplished by disposing a cylindrical rotor in a dispersion chamber and an outer stator and an inner stator surrounding the outer face and inner face of the rotor so that the dispersion system in the dispersion chamber would be of an annular type having an annular treatment gap, and circulating the dispersion medium in the annular treatment gap while rotating the rotor, discharging the dispersed material to be treated, sucking the dispersed material in the dispersion chamber again by the circulating flow in the tank, and repeating the dispersion treatment of the above annular type.

Namely, the present invention provides an immersion-type dispersing apparatus wherein a dispersion chamber containing a dispersion medium is immersed in a tank containing a material to be treated, the material to be treated is circulated into the dispersion chamber, and the material to be treated is dispersed by use of the dispersion medium moving within the dispersion chamber, which comprises

a dispersion chamber,

a cylindrical outer stator and a cylindrical inner stator disposed inside of the cylindrical outer stator for forming an annular treatment gap in

the dispersion chamber,

a rotor inserted into the treatment gap for partitioning the treatment gap into an outer gap and an inner gap,

a drive shaft rotating the rotor,

an axial flow shaft which is inserted into the inner side of the inner stator,

axial flow blades which are disposed on the axial flow shaft so as to let a material to be treated flow so that the material to be treated would flow into the treatment gap of the dispersion chamber,

a circulation port formed on the rotor so that a dispersion medium contained in the treatment gap, together with the flow of the material to be treated, would pass through the outer gap, flow in the inner gap and return to the outer gap,

a discharge port for the material to be treated, formed on the inner stator, and

a screen disposed at the discharge port, for separating the dispersion medium from the material to be treated.

The present invention also provides an immersion-type dispersing apparatus wherein the axial flow shaft rotating the axial flow blades communicates with the drive shaft.

The present invention further provides an immersion-type dispersing apparatus wherein the drive shaft rotating the rotor is formed hollow; the axial hollow shaft is permitted to pass through the drive shaft and the axial flow shaft would be connected to a different driving source and have a concentric biaxial structure, thereby controlling two shafts separately.

The present invention further provides an immersion-type dispersing apparatus wherein on appropriate sites of the rotor, outer stator, inner stator or the like, a flow-controlling surface such as unevenness, projections, spiral grooves or the like is formed, by which the impact force or grinding force by the dispersion medium is further efficiently

exerted to the material to be treated for highly improved dispersion.

BRIEF EXPLANATION OF THE DRAWINGS

Fig. 1 is a cross sectional view showing an example of the present invention.

Fig. 2 is an enlarged cross sectional view of a dispersion chamber shown in Fig. 1.

Fig. 3 is a cross sectional view showing another example of the present invention.

Figs. 4(A) and 4(B) are a plane view and a front view each showing a rotor end portion disposed at the upper portion of the rotor.

Figs. 5(A), 5(B) and 5(C) are views showing flow-controlling surfaces disposed on a rotor, an outer stator and an inner stator, respectively.

PREFERRED EMBODIMENTS OF THE INVENTION

Fig. 1 shows an example of the present invention, wherein below a frame (2) which is movable upward and downward relative to a tank (1), a dispersion chamber (4) is disposed through a rod (5) so that when the frame (2) moves downward, the dispersion chamber (4) would be immersed in a material to be treated (3) in the tank (1).

The dispersion chamber (4) has an upper plate (6) which is attached to the rod (5) and a lower (bottom) plate (8) which is connected to the upper plate (6) through a stay (7), and a cylindrical outer stator (9) is disposed between the upper plate (6) and the lower plate (8). In the inside of the stator (9), a cylindrical inner stator (10) is disposed, by which a bottomed annular treatment gap (12) is formed so as to contain dispersion medium (11)... between the stators (9) and (10). The inner stator (10) is formed integrally together with the lower plate (8) so that a through-hole would be formed at the center of the lower plate (8). However, the inner stator (10) may be formed separately from the lower plate (8) and then

attached to the lower plate(8). Further, the stators (9) and (10) are formed in a cylindrical shape. However, these may be formed in an appropriate polygonal cylindrical shape.

In the treatment gap (12), a cylindrical rotor (15) is inserted from the opening port side of the treatment gap so that the treatment gap (12) would be partitioned into an outer gap (13) and an inner gap (14), and the outer gap (13) and the inner gap (14) would communicate with each other at the bottom side of the treatment gap. The rotor (15) is attached to the lower end of a drive shaft (16), and rotated within the treatment gap (12) by rotating the drive shaft (16) by a motor not shown. In this figure, the rotor (15) is formed in a cylindrical shape. However, it may be formed in an appropriate polygonal tubular shape. The width of the treatment gap (12), particularly the width of the outer gap (13), may preferably be designed to have an appropriate width so as to exert efficiently the shearing force of the dispersion medium to the material to be treated, like the case of usual annular type dispersion system.

With the rotor (15), as shown in Fig.2, a connecting member (18) is fitted in the upper inner portion of a cylindrical rotor body (17) and is fixed by a bolt (19), and the connecting member (18) is fitted in a rotor end portion (20) and fixed by a bolt (21). In this case, a receiving groove (22) formed on the connecting member (18) is engaged with an engaging piece (23) installed on the rotor end portion (20) so as to hold the connecting member (18) against rotation. The end portion of the drive shaft (16) is inserted into the rotor end portion (20) and held against rotation, and fixed by a nut (24).

To the connecting member (18), is attached an axial flow shaft (25) which is inserted into the inside of the inner stator (10). The axial flow shaft (25) is designed to rotate together with the drive shaft (16). If the axial flow shaft (25) is installed separately from the drive shaft, the axial flow shaft can be rotated separately from the rotation of the drive

shaft (16). Fig.3 shows an example wherein the axial flow shaft and the drive shaft can be driven separately. In this figure, a hollow drive shaft (16a) is formed, and an axial flow shaft (25a) is inserted through the hollow portion of the drive shaft, by which the hollow drive shaft (16a) and the axial flow shaft (25a) are constructed to have a concentric biaxial structure. The lower portion of the axial flow shaft (25a) passes through the rotor (15) and extends toward the inside of the inner stator (10), and the upper portion of the axial flow shaft (25a) is connected to a driving source (not shown) different from the driving source for the drive shaft (16a). By separately controlling the driving sources for respective shafts, it is possible to vary the rotation speed of the rotor and the rotation speed of the axial flow shaft.

The rotor end portion (20) at the upper portion of the rotor (15) is formed in a substantially truncated conic shape. An inlet member (27) is attached to the upper plate (6) by a bolt (28) wherein the inlet member (27) has a flow-in port (26) at the center so as to cover the conical slope formed on the upper face of the rotor end portion (20). Between the rotor end portion (20) and the inlet member (27), is formed a conic gap (29) which communicates with the outer gap (13). On the outer surface of the rotor end portion (20) and/or the inner face of the inlet member (27) which define the conic gap (29), appropriate outflow-preventing projections (30) may preferably be formed so that the dispersion medium (11)... in the treatment gap would not flow in the tank from the flow-in port (26) through the conic gap (29).

Fig.4 shows an example of the outflow-preventing projections (30), wherein spirally projected outflow-preventing projections (30) are formed entirely over a conic slope (31) and a cylindrical face (32) of the rotor end portion (20), and when the rotor rotates, the dispersion medium (11)... flowing from the treatment gap (12) toward the conic gap (29) flows against the outflow-preventing projections (30) and returns to the

treatment gap (12). The outflow-preventing projections may have a structure that grooves such as spiral grooves are formed and the edges of the grooves function as the projections (not shown).

On the axial flow axis (25), axial flow blades are formed which control the flow of the material to be treated in the tank so that the material to be treated would be permitted to flow in the treatment gap of dispersion chamber. The axial flow blades may be designed variously. In the example shown in the figure, blades (33) for paddling down are disposed at the site located at the inside of the inner stator (10), and below them, an axial flow-propeller (34) is provided, and then at its lower end, turbine blades (35) are provided, thereby generating a circulation flow as shown by an arrow (A) flowing from the lower portion toward the upper portion in the tank.

At an appropriate site of the inner stator (10), a discharge portion (36) for the material to be treated is formed, and at the discharge port (36), a screen (37) having flow holes such as pores, slits or net, provided thereon is formed so as to separate the dispersion medium (11) ... from the material to be treated. At the upper portion of the inner stator (10), a sealing cap (38) is fixed by a bolt (39) so that the dispersion medium (11) ... would not flow out from the inner gap (14).

By the rotation of the axial flow shaft (25), the above circulation flow of the material to be treated is generated in the tank, and at the same time, the dispersion medium (11)... in the treatment gap (12) also flow from the outer gap (13) to the inner gap (14). On the rotor (15), a circulation port (40) is formed so that the dispersion medium (11)... which have reached the inner gap (14) would be returned to the outer gap (13). The site at which the circulation port (40) is formed, and the size, number, shape and the like of the circulation port (40), may be suitably be constructed. In the example as shown in the figure, two long slits extending axially on the periphery of the rotor body (17) are provided.

In order to control the flow of the dispersion medium (11) and the material to be treated (3) when the rotor (15) rotates, a flow-controlling surface such as unevenness, projections, long slots or spiral grooves may be formed on the surface of each member facing the outer gap (13) or the inner gap (14). As such flow-controlling surface (41), appropriate shapes, for example, screw-shaped grooves described in JP-B-3-62449 (JP-A-63-1432), spike-like projections described in JP-B-4-70050 (JP-A-1-171627), and the like, may be mentioned.

The flow-controlling surface (41) such as projections may be provided at an appropriate site taking the properties of the material to be treated and the dispersion effects into consideration. For example, these may be provided on the outer face of the rotor (15) as shown in Fig. 5(A), on the outer face of the inner stator (10) and outer faces of the rotor (15) as shown in Fig. 5(B), and on the inner and outer faces of the rotor (15), the inner face of the outer stator (9) and the outer face of the inner stator (10) as shown in Fig. 5(C).

When the flow-controlling surface (41) is provided on the entire outer face of the rotor, the movement of the dispersion medium (11)... is accelerated, and accordingly the amount of the dispersion medium (11) flowing toward the flow-in port (26) side through the conic gap (29) tends to increase. According to the results of experiments, it has been confirmed that such tendency can be suppressed by forming a flat surface (42) at a part of about $1/7$ to about $1/5$ of the height of the outer face of the rotor, and below this part, forming the flow-controlling surface (41).

In the example as shown in Fig. 1 or the like, a jacket (43) for circulating a temperature-controlling medium such as cooling water is provided at the outer side of the outer stator (9). However, the jacket may be provided on the rotor or the like, or no jacket may be provided on both sides.

Accordingly, when the dispersion chamber (4) wherein the dispersion

medium (11)... is filled in the treatment gap (12) to about 60 to 90 %, is immersed in the material to be treated (3), and then the drive shaft(16) is rotated, the rotor (15) rotates within the treatment gap (12). At that time, when the axial flow shaft (25) is connected to the drive shaft (16) as shown in Fig.1, the axial flow shaft (25) will rotate at the same time, and a circulation flow of the material to be treated will be generated in the tank. Further, when the axial flow shaft (25a) is provided separately from the drive shaft (16a) as shown in Fig.3 in a concentric biaxially style, the circulation flow of the material to be treated will be generated by rotating the axial flow shaft (25a) by a driving source different from the driving source for the drive shaft (16a).

The material to be treated circulating within the tank enters the outer gap (13) of the treatment gap (12) through the flow-in port (26) of the dispersion chamber (4), and flows in the inner gap (14). During this period, the dispersion medium (11) to which movement is given by the rotor (15) functions to finely grind the solid particles in the material to be treated by the impact force or the grinding force generated among the dispersion media, and the finely ground particles are dispersed in a liquid and then only the dispersed material is discharged into the tank through the screen (37), and by repeating this operation, the material can be dispersed to the desired dispersibility level.

When dispersion of hardly dispersible pigments was conducted by use of the apparatus as shown in Fig.1, the desired particle size (at most $0.2\ \mu\text{m}$) could be accomplished in 5 minutes of resident time, while it took 50 minutes by a conventional immersion-type dispersing apparatus.

The apparatus of the present invention is constructed as above, i.e., the material to be treated is dispersed by the annular type dispersion treatment in the dispersion chamber, leading to higher level dispersion as compared with the dispersion made by conventional stirring blades using pins or pegs. When the axial flow shaft is provided separately from the drive shaft

in a concentric biaxial style, and these are driven separately, the rotation of the rotor and the circulation flow in the tank can be controlled to the optimum conditions for the properties of the material to be treated. In addition, since the axial flow shaft is inserted into the inside of the inner stator which constitutes the dispersion chamber and the axial flow shaft can be made to have no contact with the dispersion medium, it is possible to avoid the clogging or outflow of the dispersion medium, unlike the conventional apparatuses.

Claims:



1. An immersion-type dispersing apparatus wherein a dispersion chamber containing a dispersion medium is immersed in a tank containing a material to be treated, the material to be treated is circulated into the dispersion chamber, and the material to be treated is dispersed by use of the dispersion medium moving within the dispersion chamber, which comprises:

a dispersion chamber,

a cylindrical outer stator and a cylindrical inner stator disposed inside of the cylindrical outer stator for forming an annular treatment gap in the dispersion chamber,

a rotor inserted into the treatment gap for partitioning the treatment gap into an outer gap and an inner gap,

a drive shaft for rotating the rotor,

an axial flow shaft which is inserted into the inner side of the inner stator,

axial flow blades which are disposed on the axial flow shaft so as to let a material to be treated flow so that the material to be treated would flow into the treatment gap of the dispersion chamber,

a circulation port formed on the rotor so that a dispersion medium contained in the treatment gap, together with the flow of the material to be treated, would pass through the outer gap, flow in the inner gap and return to the outer gap,

a discharge port for the material to be treated, formed on the inner stator, and

a screen disposed at the discharge port, for separating the dispersion medium from the material to be treated.

2. An immersion-type dispersing apparatus according to Claim 1, wherein the axial flow shaft rotating the axial flow blades communicates with the

drive shaft.



3. An immersion-type dispersing apparatus according to claim 1, wherein the drive shaft rotating the rotor is formed hollow; the axial flow shaft is permitted to pass through hollow drive shaft and the lower end of the axial flow shaft is inserted into the inner side of the inner stator.
4. The immersion-type dispersing apparatus according to Claim 1, wherein a flow-controlling surface such as unevenness, projections, spiral grooves or the like is formed on the outer side of the rotor.
5. The immersion-type dispersing apparatus according to Claim 4, wherein the flow-controlling surface is formed on the outer face of the rotor and the outer face of the inner stator.
6. The immersion-type dispersing apparatus according to Claim 4, wherein the flow-controlling surface is formed on the inner and outer faces of the rotor, the inner face of the outer stator, and the outer face of the inner stator.
7. The immersion-type dispersing apparatus according to Claim 4, wherein about $1/7$ to about $1/5$ in height from the uppermost part of the outer face of the rotor is a flat face, and below the flat face, the flow-controlling surface is formed.
8. The immersion-type dispersing apparatus according to Claim 1, wherein an upper portion of the rotor is formed in a substantially conic shape, and an inlet member is faced to the upper portion wherein the inlet member has a flow-in port at the center and covers the upper portion of the rotor, and between the inlet member and the upper portion of the rotor, a conic gap

which communicates with the outer gap is formed.



9. The immersion-type dispersing apparatus according to Claim 8, wherein projections for preventing outflow of the dispersion medium are formed on the outer face of the rotor and/or the inner face of the inlet member, which faces the conic gap.