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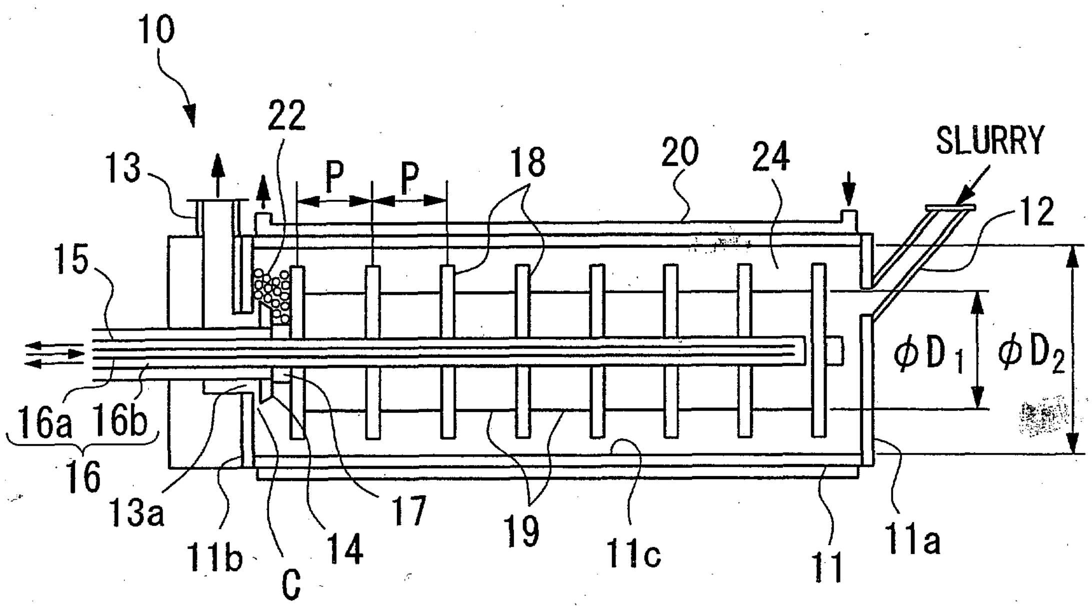
(54) Dispersion apparatus and dispersion method

(57) A dispersion apparatus and a dispersion method are provided which enable process material to be dispersed efficiently without causing an increase in driving force, and the quality of processed material to be improved. In this dispersion apparatus and method, rotors (19) and agitating discs (18) are fixed alternately on a main shaft (15) in a cylinder (11) to rotate in unison. The outside diameter of the rotors (19) is D1, the inside diameter of the cylinder is D2, and D1/D2 is set in a range of 0.4 to 0.7. The ratio D1/P of the array pitch P of the agitating discs (18) and the outside diameter D1 of the rotors is set in a range of 1.4 to 3.0.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a dispersion apparatus and a dispersion method, which is used to atomize, agitate, and the like, a range of slurries of, for example, paint, printing ink, pharmaceuticals, food, and the like, for dispersion processing.

Description of the Related Art

[0002] Heretofore, in the fields of paint, printing ink, pharmaceuticals, food, and the like, a range of slurries, being materials, have undergone dispersion processing such as agitation, atomization, fine mixing, or the like, to make finished products.

[0003] Among them, in the field of printing ink, pigment is dispersed in a vehicle formed of resin together with varnish, additives and solvent to create base ink with high pigment concentration, which is then diluted to make the finished ink. For example, in the case of a base ink with comparatively high viscosity, typically milled base ink in which pigment, varnish, solvent and the like are mixed, is milled by a bead mill, a roll mill or the like, additives or the like are added and adjustment then made for production.

[0004] When milling the base ink, if the dispersion of the pigment is insufficient, it detrimentally influences the quality stability, such as density, gloss, transparency, and printability. As dispersion apparatus used in milling processes, the productivity of roll mills and ball mills is poor because they are not continuous systems, and in particular, roll mills also have safety and working environment problems.

[0005] On the other hand, a dispersion apparatus such as a media agitating mill or the like accommodates a lot of granular media in a cylinder, and milled base ink, being rough ink, is injected, and is agitated together with the granular media by agitating members such as pins installed on a rotating shaft, discs, or the like, for dispersion mixing. The granular media agitated and dispersed in the cylinder crush and refine milled base ink, thus dispersion and milling proceed, so that there is an advantage that the productivity is high.

[0006] There are vertical cylinder and horizontal cylinder type media agitating mills. The vertical cylinder type has a high load in its axis of rotation in a dispersion process of base ink with comparatively high viscosity when the apparatus is started, and the dispersion efficiency of milled base ink drops due to congestion of granular media, and a phenomenon called choking occurs in which granular media accumulates in the vicinity of the ink discharge side, so that there is a deficiency that stable operation is not possible.

[0007] On the other hand, the horizontal cylinder type has become popular in recent years since it has no deficiency as described above. In a horizontal cylinder type dispersion apparatus, drive torque is low, and maintenance of the cylinders and rotating shaft is easy, so there is an advantage that the apparatus is inexpensive.

[0008] An example of such a horizontal cylinder type is a media agitating type mill disclosed in a Japanese Unexamined Patent Application, First Publication No. 9-225279.

[0009] This media agitating type mill has a structure as shown in FIG. 9. This mill 1 has beads 6 loaded in advance as media in a cylinder 2, a rotating shaft 3, and also agitating discs 4 are fitted along the rotating shaft at a predetermined spacing. In the agitating discs 4, cut slots with a width through which beads can pass, are formed at a predetermined spacing, and there are open holes through which beads can pass inside the cut slots.

[0010] In this media mixing type mill 1, when slurry such as milled base ink or the like is supplied from an inlet 5, the slurry is crushed and dispersed together with the beads 6 by the rotation of the rotating shaft 3 and the mixing discs 4. Using this mill 1, especially if the slurry has a high viscosity, or the compression conveying amount is large, the beads 6 are pushed toward the outlet side of the cylinder 2 by the slurry supply, and the slurry is discharged through the aperture in the outlet, but the beads 6 accumulate in the vicinity of the outlet. Afterwards, the beads 6 perform a circulatory motion by being scattered by the rotating shaft 3 and the mixing discs 4, and being transferred to the inlet side through the open holes of the mixing discs 4. Consequently, even if the slurry has a high viscosity, and the compression conveying amount is large, the beads 6 are prevented from being unevenly distributed on the outlet side, and are circulated, thus enabling the slurry to be crushed and dispersed.

[0011] However, in such a media mixing type mill 1, if the outside diameter of the rotating shaft 3 is D1, and the inside diameter of the cylinder 2 is D2, the ratio D1/D2 is set to 0.3 or lower, and the peripheral speed around the outer peripheral surface of the rotating shaft 3 is comparatively low. Hence there is little movement of the beads 6, and the capacity of the crushing chamber (milling zone), which is formed by the inside surface of the cylinder 2, the rotating shaft 3 and the agitating discs 4, is large. Consequently, as shown in FIG. 10, the distance between the rotating shaft 3 and the cylinder 2 is large, and the movement of the beads 6 is small, resulting in a significant drop in fluidity, especially of slurry with high viscoelasticity. Furthermore, in the vicinity of the cylinder inner wall, since agitating efficiency is poor, agglomerations are formed from the slurry and the beads 6, which adhere easily, so that there is a deficiency that stable operation of the rotating shaft 3 is not possible due to dispersion failure and load increase.

[0012] In particular, with high viscosity slurry whose viscosity is 5000mPa·s or more, the load is great, so that the fluidity of the beads 6 is inhibited, and a phenomenon called co-rotation in which an agglomeration of beads 6 and slurry flows together with the rotating shaft 3 and the agitating discs 4 can occur. Consequently, there is a disadvantage of a high load on the rotating shaft 3, and that the dispersion process does not continue, so that a deficiency is possible where processed slurry solution does not come out from the cylinder.

[0013] Furthermore, Japanese Unexamined Patent Application, First Publication No. 6-114254 discloses a technique in which a throttle valve is placed on the discharge side of a cylinder, and the inside of the cylinder is pressurized for dispersion processing by tightening the valve. The occurrence of a short pass of slurry is suppressed to a certain degree by the increase in the internal pressure. However, it causes frictional heating and a rapid increase in the load in the shaft due to overcrowded contact of granular media, so that there are disadvantages that the physical properties of the slurry are influenced detrimentally, or stable operation is not possible, and the like. Moreover, it leads to a deficiency in that uniformity of the dispersion conditions of the slurry is lost.

SUMMARY OF THE INVENTION

[0014] The present invention takes such a situation into consideration, with an object of providing a dispersion apparatus and a dispersion method that enable efficient dispersion processing of process material, without causing an increase in the driving force.

[0015] Another object of the present invention is to perform a dispersion process while controlling increases in internal heat, and without any detrimental influence to the physical properties of the process material.

[0016] According to the present invention, the above objects are achieved by a dispersion apparatus as defined in claim 1 and a dispersion method as defined in claim 7, respectively. The dependent claims define advantageous and preferred embodiments of the invention.

[0017] The preset invention is characterized in that there are provided rotors in a cylinder, and agitating members, which protrude from the rotors radially, are positioned at a predetermined spacing in the longitudinal direction of the rotors, and when performing dispersion processing by agitating the process material injected into the cylinder together with media, a ratio D1/D2 between an outside diameter D1 of the rotors installed in the cylinder and an inside diameter D2 of the cylinder is set to be in a range of 0.4 to 0.7.

[0018] Since the outside diameter D1 of the rotors is large, high kinetic energy is imparted to the media around the outer peripheral surface of the rotors when rotating, which makes the beads and the process material accumulating in the vicinity of the internal circumference of the cylinder collide and disperse, and loss of motion can be reduced, so that the dispersion process of crushing and agitating the process material in the cylinder can be performed efficiently even though the capacity of the cylinder is reduced. Thus both processing quality and productivity can be improved. Furthermore, no increase in driving force is required for the processing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] A dispersion apparatus according to the present invention is a dispersion apparatus in which there are provided rotors in a cylinder, and a plurality of agitating members which protrude from the rotors in a radial direction, positioned at a predetermined spacing in a longitudinal direction of the rotors, and process material injected into the cylinder is agitated together with media to disperse the process material, wherein the outside diameter of the rotors is D1, the inside diameter of the cylinder is D2, and a ratio D1/D2 is set in a range of 0.4 to 0.7.

[0020] When the rotors are rotated in the cylinder, since the outside diameter D1 of the rotors is large, it is possible to disperse the process material by giving the media around the outer peripheral surface of the rotors a high kinetic energy, and making the media collide with the beads (media) and the processed material accumulating in the vicinity of the internal circumference of the cylinder, thus enabling loss of motion to be reduced, and since the process material is supplied to the cylinder continuously, the dispersion processing by crushing and agitating the process material in the cylinder can be performed efficiently even though the capacity of the cylinder is reduced. If the ratio D1/D2 is below 0.4, kinetic energy loss of the granular media accompanying the increase of the distance between the rotor and the cylinder is high, which leads to short passing of the process material and poor dispersion. Hence there is a disadvantage of processing efficiency falling. On the other hand, if the ratio D1/D2 exceeds 0.7, the difference in size between the outside diameter of the rotors and the agitating members is too low. Hence there are deficiencies such as being unable to obtain an adequate effect from the agitating members, and easily inviting overcrowding due to poor flow of the media.

[0021] The process material may be a slurry or process liquid such as printing ink, or the like.

[0022] Furthermore, a ratio D1/P between the array pitch P of the agitating members and the outside diameter D1 of the rotors may be set in a range of 1.4 to 3.0, so that the motion of media in the cylinder is good, and the process material injected thereinto flows in a form of laminar flow, so that the processing quality is improved. If it is 1.4 or more, then the spacing between the agitating members is not too large, which prevents the motion of media from dropping, thus enabling the process material to be crushed and dispersed sufficiently. Moreover, if it is 3.0 or less, then the spacing between the agitating members is not too narrow, and does not cause the media to be unevenly distributed or drift, thus enabling stable operation.

[0023] In addition, the array pitch P of the agitating members does not always need to be a fixed spacing, and the spacing may be changed depending on the nature of the process material. For example, if it narrows from the inlet toward the outlet, it is possible to intensify the dispersion force gradually.

[0024] A cooling device may be provided in the rotor, and furthermore a cooling device may be provided outside the cylinder, which prevents the physical properties of the process material from changing by temperature increase, and it is especially useful for process material whose nature changes easily with temperature, such as gravure ink and the like.

[0025] The agitating members may be a plurality of pins installed outside of a rotating shaft, as shown in FIG. 7, or discs, especially discs provided with a plurality of holes (through holes) passing through the discs, as shown in FIG. 6, installed on a rotating shaft. In considering the prevention of a short pass by dispersing the media uniformly in the processing chamber and circulating it appropriately, a type of disc is preferable that has a plurality of slot openings in the outer periphery of the disc other than the plurality of through holes.

[0026] Especially, in the case where the viscosity of the process material is high, the number of notched slots is 3 to 15, and preferably 4 to 12, in order to make the media flow quickly and increase the circulation force, although it depends on the capacity of the crushing chamber. Furthermore, the number of through holes is preferably about 3 to 8.

[0027] A dispersion method according to the present invention is characterized in that there are provided rotors and agitating members protruding outside of the rotors in a radial direction in a cylinder, and an outside diameter of the rotors is D1, an inside diameter of the cylinder is D2, a ratio D1/D2 is set in a range of 0.4 to 0.7, slurry, being process material, is injected into the cylinder, and the rotors and agitating members are rotated to agitate the slurry together with the media for the purpose of dispersion processing.

[0028] Whether the viscosity of the process material is high, or the viscosity of the process material is low, since as the peripheral speed of the rotors increases and the distance between the rotors and the internal circumference surface of the cylinder becomes short, the process material and the media collide around the internal circumference surface of the cylinder in a state that the kinetic energy for scattering the media is high, and the loss is small, it is possible to perform dispersion processing of the process material efficiently. Furthermore, it is also possible to suppress local congestion of the media and a phenomenon of choking, which tend to occur in the case of low viscosity.

[0029] In addition, where an array pitch of the agitating members is P, a ratio with the outside diameter D1 of the rotors, D1/P, may be set in a range of 1.4 to 3.0, and this enables the dispersion processing of the process material to proceed more reliably.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a schematic block diagram of a dispersion apparatus according to an embodiment of the present invention.
FIG. 2 is a block diagram of the main part of the dispersion apparatus shown in FIG. 1.
FIG. 3 is a plan view of an example of an agitating disc mounted in the dispersion apparatus shown in FIG. 1.
FIG. 4 is a plan view of another example of an agitating disc mounted in the dispersion apparatus shown in FIG. 1.
FIG. 5 is a plan view of another example of an agitating disc mounted in the dispersion apparatus shown in FIG. 1.
FIG. 6 is a plan view of another example of an agitating disc mounted in the dispersion apparatus shown in FIG. 1.
FIG. 7 is a plan view of another example of an agitating member mounted in the dispersion apparatus shown in FIG. 1.
FIG. 8 is a schematic block diagram of a dispersion apparatus according to a second embodiment.
FIG. 9 is a schematic block diagram of a conventional dispersion apparatus.
FIG. 10 shows a state in which beads accumulate in the dispersion apparatus shown in FIG. 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] FIG. 1 through FIG. 7 show a dispersion apparatus according to a first embodiment. FIG. 1 is a schematic block diagram of a longitudinal section of the dispersion apparatus, FIG. 2 is a partial side view of the dispersion apparatus shown in FIG. 1, and FIG. 3 is a plan view of an agitating member.

[0032] A dispersion apparatus 10 in the embodiment as shown in FIG. 1 and FIG. 2 is a media agitating mill or the like, for example, which has an approximately cylindrically shaped cylinder 11, an inlet 12 for slurry (process material) such as ink and the like, for example, formed on one end plate 11a of the cylinder 11, and an outlet 13 for discharging slurry that has been injected into the cylinder 11, dispersed and milled, formed on the other end plate 11b opposite the end plate 11a. A separator 14 is fitted over an aperture 13a leading to the cylinder 11 via a gap C, and dispersed and milled slurry is discharged through the gap C between the separator 14 and the aperture 13a. The gap C does not allow media loaded in the cylinder 11 to pass through, for example granular shaped beads 22, but it is designed to pass small diameter slurry.

[0033] Furthermore, a main shaft 15 is inserted into the cylinder 11 substantially coaxially with the cylinder 11, passing through the outlet 13 and the separator 14, and disposed such that it can rotate relative to the internal surface of the cylinder 11. An internal cooling path 16 is formed in the main shaft 15 as a cooling device for cooling media such as cooling water or the like to circulate, and this cools the slurry inside the cylinder 11. The internal cooling path 16 comprises an entry pipe 16a for supplying cooling water, and a return pipe 16b, for example. An external cooling path 20 is also provided in the outer periphery of the cylinder 11, which circulates cooling media such as cooling water or the like to cool the inside of the cylinder 11.

[0034] In the cylinder 11, a plurality of agitating discs 18 (agitating members) and a plurality of rotors 19 are fitted alternately and coaxially, via a ring-shaped spacer 17 from the separator 14 side, on the main shaft 15.

[0035] FIG. 3 shows one example of a case where the agitating members are agitating discs. In FIG. 3, agitating discs 18 appear approximately disc shaped with a larger outside diameter than the rotors 19 as shown in this figure. A plurality (4 in the figure) of slots 21 are provided in the agitating disc 18 around its outer periphery at a predetermined spacing in the circumferential direction. The slots 21 curve inward from the outer peripheral surface toward the center extending forward in the direction of rotation. The slots 21 are formed such that the width in the circumferential direction is larger than the outside diameter of the beads 22, which allows the beads 22 to pass through.

[0036] Furthermore, through holes 23 are punched between adjacent slots 21 in the agitating discs 18 at a predetermined spacing in the circumferential direction, close to the rotor 19. The beads 22 can also pass through the through holes 23, which enables a large number of beads 22 gathered on the outlet 13 side of the cylinder 11 to pass through and move to the inlet 12 side.

[0037] The rotors 19 located between adjacent agitating discs 18 are substantially cylindrically shaped, with a smaller diameter than the agitating discs 18, and the internal cooling path 16 circulates inside them (not shown in the figure). The agitating discs 18 and the rotors 19 are fitted alternately and coaxially on the main shaft 15, and fixed so as to rotate together with the main shaft 15.

[0038] In FIG. 1, agitating discs 18 are fitted on both ends. However, alternatively, the construction may be such that rotors 19 are fitted on both ends. In other words, the agitating discs 18 and the rotors 19 may be arranged alternately, or the agitating discs 18 may be arranged on a rotor 19 formed as a long shaft, at a predetermined spacing. The space between the internal circumference surface 11c of the cylinder 11, and the agitating discs 18 and the rotors 19 forms a crushing chamber 24 (milling zone) into which the beads 22 and slurry are loaded.

[0039] FIGS. 4 to 7 show examples of other agitating members which are used in the present invention. FIG. 4 shows a disc 18 having more slots and through holes 23 than the agitating disc shown in FIG. 3. Numeral 19 denotes a rotor. FIG. 5 shows a disc 18 having slots 21 and no through holes. In this figure, numeral 19 denotes a rotor. FIG. 6 shows a disc 18 having through holes 23 but no slots. In this figure, numeral 19 denotes a rotor. FIG. 7 shows an agitating member having pins 18a instead of a disc. In this figure, numeral 19 denotes a rotor. Numeral 11c indicates the inside of the cylinder.

[0040] A large number of granular beads 22 is held in the cylinder, and the beads 22 which are scattered to the inner surface 11c of the cylinder 11 by the rotation of the rotors 19 and the agitating discs 18, collide with injected slurry and accumulated beads 22, and crush and disperse the slurry, which is sent toward the outlet 13 side continuously as it repeats.

[0041] The beads 22 appear almost spherical for example, and their average particle size is set to about 0.2 to 3mm. Furthermore, the beads 22 fill up approximately 65 to 95% of the volume of the cylinder 11, and the filling percentage is determined appropriately depending on the nature of the slurry including pigment and the like to be crushed, for example how easy it is to crush, or the particle size before crushing and the like. Furthermore, the material of the beads 22 used is selected depending on the properties of the slurry, for example viscosity, specific gravity, required grain size for pulverization and dispersion, and the like, and for example, glass beads, zircon beads, zirconia beads, steel balls or the like are used. However, in general, material that has high specific gravity and is difficult to abrade is preferable. If the viscosity of slurry, such as ink, is high, beads 22 with high specific gravity are selected.

[0042] Since steel beads generally generate black iron powder by collision, friction, and the like, it is used for India ink type ink, and the like, while in the case of whitish ink, beads such as zirconia are used. In the case of slurry with low viscosity, glass beads are used typically.

[0043] In general, beads 22 having a particle size five to six times the initial particle size of the injected slurry may be used. In dispersion processing of slurry, there are both a case where it is processed to the required particle size by a single stage dispersion apparatus, and a case where it is passed through a plurality of processing stages using a plurality of dispersion apparatuses in which beads with different particle sizes are loaded, and it is dispersed to the required particle size gradually.

[0044] In the case where the outside diameter of the rotors 19 is D1, and the inside diameter of the cylinder 11 is D2, the ratio of the two D1/D2 is set in a range of 0.4 to 0.7. If the ratio D1/D2 is set in this range, the peripheral speed of the outer periphery of the rotors 19 can be set high, and furthermore the distance to the internal circumference surface 11c of the cylinder can be set short. Hence, loss of the kinetic energy for scattering the beads 22 is low, thus enabling efficient crushing and dispersion of slurry. If it is below 0.4, since the outside diameter of the rotors 19 is decreased, the distance to the internal circumference surface 11c of the cylinder increases, the kinetic energy loss of the beads 22 is high, so that there is a disadvantage in that it causes a short pass and dispersion failure easily. Furthermore, it is difficult to obtain space for the internal cooling path 16, so that there is a disadvantage in that sufficient cooling area cannot be obtained on the surface of the rotors 19 in the structure. If the agitating discs 18 have no slots 21, the agitation and scattering efficiencies of the beads 22 fall significantly.

[0045] In the case where the pitch between adjacent agitating discs 18 is P, the ratio D1/P with the outside diameter D1 of the rotors 19 is set in a range of 1.4 to 3.0. If the ratio D1/P is set in this range, motion of the beads 22 in the cylinder 11 can be maintained satisfactorily, so that it is possible to prevent drift and a phenomenon of choking of the beads 22 due to the velocity of the injected slurry. If it is 1.4 or more, then the spacing between the agitating discs 18 is not too large, which prevents the motion of media from deteriorating, thus enabling the process material to be crushed and dispersed sufficiently. Moreover, if it is 3.0 or less, then the spacing between the agitating discs 18 is not too narrow, so that uneven distribution and drift of the media (beads 22) is prevented, thus enabling stable operation.

[0046] In addition, the array pitch P of the agitating members does not always need to be a fixed spacing, and the spacing may be changed depending on the nature of the process material. For example, if it narrows from the inlet 12 toward the outlet 13, it is possible to intensify the dispersion force gradually.

[0047] A dispersion apparatus 10 according to the present embodiment has the above-described structure. Next is a description of a dispersion method.

[0048] In the dispersion apparatus 10 shown in FIG. 1 and FIG. 2, the beads 22 are loaded in advance into the crushing chamber 24 defined by the cylinder internal circumference surface 11c, the agitating discs 18, and the rotors 19 in the cylinder 11. Slurry is supplied from the inlet 12 to the cylinder 11 continuously, and at the same time by rotating the main shaft 15, which is linked to a drive source (not shown in the figure), at a predetermined speed, the agitating discs 18 and the rotors 19 rotate in unison. At this time, the speed of the outer periphery of the agitating discs 18 is approximately 7 to 18m/s, and preferably approximately 10 to 15m/s.

[0049] In FIG. 3, by rotating the agitating discs 18 in the direction of the arrow, the slurry is agitated together with the beads 22 and dispersed. The beads 22 are scattered to the internal circumference surface 11c of the cylinder 11 by the agitating discs 12, collide with the slurry and beads 22 accumulating around the internal circumference surface 11c, and crush and refine the slurry particles. The rotors 19 rotating in unison with the discs 18 have large diameters, so the peripheral speed of the outer peripheral surface is high. Thus the beads 22 and the slurry accumulating around the outer periphery of the rotors 19 fly toward the cylinder internal circumference surface 11c by centrifugal force.

[0050] Here, in a conventional dispersion apparatus, since the ratio D1/D2 is small, being 0.3 or less, the distance to travel to the cylinder internal circumference surface is long, and also the kinetic energy loss is high due to the viscoelasticity of slurry which collides while traveling. Especially in the case where the slurry has high viscosity characteristics, the energy loss is high. Furthermore, if the periphery of the internal circumference surface 11c of the cylinder 11 is cooled by the external cooling path 20, the viscosity of the slurry in this region becomes high, thus causing the energy loss to increase further.

[0051] However, according to the present embodiment, since the ratio D1/D2 is large, being 0.4 or more, the cross section (capacity) of the crushing chamber 24 is reduced, but the kinetic energy of the beads 22, which are scattered by high speed because of the short distance to the cylinder internal circumference surface 11c, work the slurry, which has comparatively high viscosity, around the cylinder internal circumference surface 11c sufficiently to crush it, so that energy loss can be avoided.

[0052] In this manner, there is no dead space in the vicinity of the rotors 19 and the internal circumference surface 11c, the slurry in this space can be dispersed, and the beads 22 can also be moved, thus enabling homogeneous atomization and dispersion of the slurry.

[0053] The beads 22 and the slurry in the crushing chamber 24 of the cylinder 11 are sent to the outlet 13 side gradually by the supply pressure of the slurry supplied continuously from the inlet 12. A gap C between the separator 14 and the aperture 13a of the outlet 13 prevents the beads 22 from passing through, but lets atomized slurry pass through, so that only dispersed slurry is discharged from the outlet 13 and recovered.

[0054] That means that the beads 22 left in the vicinity of the outlet 13 accumulate between the agitating disc 18 on the outlet 13 side and the other end face 11b of the cylinder as shown in FIG. 1 and FIG. 2, but are returned to the inlet 12 side through through holes 23 in this agitating disc 18. In this case, if the agitating disc 18 close to the outlet

13 is fitted slightly off the center of the rotor 19, it is easy to scatter the beads 22, which enables the degree of recirculation of the beads 22 to be increased. Furthermore, on the discharge side, the beads 22 are normally in an overfilled state, but if the separator 14 is positioned off the center of the rotor 19, the effect of scattering the beads 22 increases, which enables the recirculation of the beads to be further increased.

[0055] In this manner, while the beads 22 are being circulated in the longitudinal direction of the rotors 19 in the cylinder 11, slurry supplied continuously from the inlet 12 can be dispersed and discharged continuously. According to the present embodiment, since the ratio D1/D2 is set high, the cross section of the crushing chamber 24 is reduced by about 20 to 30% from a conventional dispersion apparatus. However, the outside diameter of the rotors 19 is increased, and the peripheral speed can be improved by two or more times, so that dispersion processing efficiency in the cylinder 11 is increased, and the residence time of the slurry is shortened. Moreover, since the dispersion efficiency is good, better processing quality can be obtained than with a conventional dispersion apparatus.

[0056] Furthermore, in a conventional dispersion apparatus, if the feed rate of slurry is increased, the internal pressure of the cylinder increases and is converted into thermal energy, which sometimes affects the physical properties of slurry. However, in the dispersion apparatus 10 according to the present embodiment, since the accumulation time of slurry is shortened, the increase of the internal pressure is only in the range of 0 to 0.01MPa with a normal feed rate in the range of 100 to 300kg/h, and hence no problem occurs. Moreover, in the present embodiment, the increase of the internal temperature can be suppressed by cooling by the internal cooling path 16 in the rotors 19 as well as by cooling by the external cooling path 20 of the cylinder 11.

[0057] According to the present embodiment described above, high kinetic energy is given to the beads 22 in the cylinder 11, and at the same time motion loss is reduced, so that the dispersion processing of crushing and agitating slurry in the cylinder 11 can be performed efficiently and satisfactorily even though the capacity of the crushing chamber 24 is reduced, and thus processing quality can be improved. Furthermore, no increase in driving force is required for the processing. Moreover, dispersion processing can be performed over a wide range from low viscosity (for example, 100mPa·s) slurry to high viscosity (for example, 100,000mPa·s) slurry.

[0058] Next is a description of a second embodiment of the present invention using FIG. 8.

[0059] A dispersion apparatus as shown in FIG. 8 has almost the same structure as the first embodiment, so the same symbols are used for the same parts, and descriptions are omitted.

[0060] In a dispersion apparatus 30 as shown in FIG. 8, a plurality of agitating discs 18 is fitted on a main shaft 31 installed in a cylinder 11 at a predetermined spacing, and cylindrical collar rings 32 are mounted on the outer peripheral surface of the main shaft 31 as rotors between adjacent agitating discs 18. The outer peripheral surface of the collar rings 32 has the same outside diameter D1 as the outer peripheral surfaces of the rotors 19, and the numerical ranges of ratios D1/D2 and D1/P are the same as in the first embodiment. The collar rings 32 and the agitating discs 18 rotate in unison with the main shaft 31.

[0061] Therefore, a dispersion apparatus 30 according to the second embodiment exhibits the same effects as the first embodiment. Specifically according to the present embodiment, by changing the collar rings 30, it is possible to adjust the outside diameter D1 and the pitch P of the agitating discs 18, so that there is an advantage in that it can be adjusted to the type of slurry, degree of dispersion, and the like.

[0062] In the embodiments described above, the agitating discs 18 are basically fitted coaxially on main shafts 15 and 31, but they are not always coaxial, and may be fitted off center.

[0063] Furthermore, the agitating discs 18 and the rotors 19 or the collar rings 32 are not limited to separate pieces, and they may be constructed as one piece. In this case, the main shafts 15 and 31 may also be constructed as one piece, or may be separate pieces.

[0064] Moreover, it is possible to set the numbers of slots 21 and through holes 23 of the agitating discs 18 as desired.

[0065] In the embodiments described above, printing ink is used as the process material. However, the present invention is not limited to this, and it may be used for a range of slurries or process liquids, such as can coatings, metal and automotive coatings, batteries and magnetic coatings, pulp and the like.

[Experimental Examples]

[0066] Next is a description of experimental examples of the present invention.

[0067] Examples 1, 2, 3, 4, 5, 6, 7 and 8 and Comparative Examples 1, 2, 3, 4, 5, 6 and 8 have the same structure as the dispersion apparatus 10 according to the first embodiment, and the outside diameters D1 of the rotors 19 vary as shown in Table 1 and Table 2 following. Accordingly, there are differences in ratios D1/D2 and D1/P, volume of the crushing chamber 24, shaft power and the like.

[0068] Firstly, experiments were performed on Examples 1 to 5 and Comparative Examples 1 to 5.

(1) Specimens 1 and 2

[0069] Gravure base inks having the following compositions were used for specimens 1 and 2, being slurries.

Specimen 1

Name: Gravure Base Ink
Pigment: Copper Phthalocyanine Blue
Pigment content 22 weight %, remainder Cellulose Nitrate Resin or the like

Specimen 2

Name: Gravure Base Ink
Pigment: Azo Yellow
Pigment content 20 weight%, remainder Cellulose Nitrate Resin or the like

[0070] Furthermore, specimens 1 and 2 were created using the following procedure.
[0071] The above-described gravure base inks were each charged into a 400L (liter) open tank, agitated by a single shaft agitator with 10 inch diameter discs at a rotation speed of $1000 min^{-1}$ for one hour, and 200kg was used for a dispersion test by a dispersion apparatus (media agitating mill). The viscosities after agitation were 2500mPa·s for specimen 1, and 1500mPa·s for specimen 2.
[0072] The viscosities were measured using a Viscotester VT04 brand of B type viscometer (manufactured by Rion Co. Ltd.). The measurement temperature was 25°C.

(2) Common Operation Test Conditions of Specimens 1 and 2

[0073]

Beads 22

Bead Type: Zirconia YTZ (Manufactured by Nikkato Corporation)
Bead Diameter: 1mm
True Specific Gravity: 6.00 Apparent Specific Gravity: 3.6
Bead Filling Rate: 85%

Peripheral Speed of Outer Peripheral Surface of Agitating Discs 18: 13.5m/s

(3) Evaluation of Dispersibility

1. Comparison of Productivity

[0074] The processed specimens 1 and 2 were measured using a grind gage, and the evaluation was performed based on the amount processed per hour when a maximum of 5μm was reached. The large amount of ink processed indicated a higher capability for the same quality. For dispersion efficiency, a comparison was made of the same specimen where:

dispersion efficiency = throughput in the example/throughput in the comparative example.

2. Quality

[0075] The gravure base ink obtained by dispersion processing was spread onto a 25μm PET film by a bar coater #7, and a quality evaluation of the film surface on which the color was spread was made using a 60° mirror reflectivity gloss meter. The quality of the gravure ink of specimens 1 and 2 was higher as the brightness value was increased.
[0076] A bar coater coats a film to a fixed thickness rapidly and accurately. It has thin lines circling around the rod surface, and is designated by a number based on the thickness of the thin lines. The bar coater used was; material: SUS304, Rod: 8mm diameter × 300mm length (effective length 250 mm), type: No. 7, Manufactured by Dai-Ichi Rika Co. Ltd.

[0077] Furthermore, for the gloss meter, a GM-3 type photometer manufactured by Murakami Color Research Laboratory was used, and 60° mirror reflectivity was used as an evaluation value. The method of measuring specular glossiness was JIS Z8741.

(4) Comparative Evaluation

[0078] Operations on specimens 1 and 2 were performed using a dispersion apparatus as in Example 1 and Comparative Example 1, in which the ratios D1/D2 varied as shown in the following Table 1, and the results were compared. Similarly, operations were performed on each of Examples 2 to 5 and Comparative Examples 2 to 5, and the results were compared.

Table 1

	Specimen	Crushing Chamber Capacity (liter)	Shaft Power (kW)	D1: Rotors Outside Diameter (mm)	P: Agitating Members Pitch (mm)	D2: Cylinder Inside Diameter (mm)	D1/P (-)	D1/D2 (-)	Ink Though-put (kg/h)	Dispersion Efficiency	Through-put per Crushing Chamber (kg/h·L)	Glossiness 60° Reflectivity (%)
Example 1	Specimen 1	4.0	10	95	43	150	2.21	0.633	35	1.40	8.75	68.2
Comparative Example 1	Specimen 1	5.6	13	36	43	150	0.84	0.240	25	1.00	4.46	65.5
Example 2	Specimen 1	15.8	22	116	53	220	2.19	0.527	80	1.23	5.06	67.9
Comparative Example 2	Specimen 1	20.0	25	50	53	220	0.94	0.227	65	1.00	3.25	64.9
Example 3	Specimen 1	25.5	24	126	76	250	1.66	0.504	120	1.26	4.71	68.0
Comparative Example 3	Specimen 1	30.0	27	69	76	250	0.91	0.276	95	1.00	3.17	66.1
Example 4	Specimen 2	4.0	8	95	43	150	2.21	0.633	60	1.25	15.00	70.4
Comparative Example 4	Specimen 2	5.6	12	36	43	150	0.84	0.240	48	1.00	8.57	66.3
Example 5	Specimen 2	25.5	24	126	76	250	1.66	0.504	90	1.29	3.53	71.2
Comparative Example 5	Specimen 2	30.0	27	69	76	250	0.91	0.276	70	1.00	2.33	65.8

[0079] Next, experiments were performed using other specimens for Examples 6 to 8 and Comparative Examples 6 and 8.

(1) Specimens 3 and 4

[0080] Lithographic base inks having the following compositions were used for specimens 3 and 4, being slurries.

Specimen 3 Name: Lithographic Base Ink
Pigment: Carbon Black
Pigment content 40 weight %, remainder Resin Varnish or the like
Specimen 4 Name: Lithographic Base Ink
Pigment: Carbon Black
Pigment content 40 weight %, remainder Resin Varnish or the like

[0081] Specimens 3 and 4 were created using the following procedure.
[0082] Specimen 3 was agitated by a single shaft agitator with 8 inch diameter discs at a rotation speed of $1000min^{-1}$ for two hours, and 50kg was used for a dispersion test by a dispersion apparatus (media agitating mill). The viscosity of specimen 3 was 58000mPa·s.
[0083] Specimen 4 was agitated by a double concentric shaft agitator for two hours. The inner high-speed agitating blade was rotated at $700min^{-1}$, and the outer constant speed agitating blade at $20min^{-1}$. 800kg was used for the dispersion test by a dispersion apparatus (media agitating mill). The viscosity of the specimen 4 was 15000mPa·s.
[0084] Viscosity measurement was performed using the same measuring device as specimens 1 and 2 under the same conditions.

(2) Common Operation Test Conditions of Specimens 3 and 4

[0085]

Beads 22

Bead Type: Steel (chromium) SUJ-2 (Manufactured by Daido Kogyo Co,. Ltd)
Bead Diameter: 2mm
True Specific Gravity: 8.00 Apparent Specific Gravity: 4.68
Bead Filling Rate: 85%

Peripheral Speed of Outer Peripheral Surface of Agitating Discs 18: 13.5m/s

(3) Evaluation of Dispersibility

1. Comparison of Productivity

[0086] The dispersion processed specimens were measured using a grind gage, and the evaluation was performed based on the amount processed per hour when a maximum of 10µm was reached. Other matters were the same as in the case of specimens 1 and 2. The method of evaluating malaxation degree by a grind meter was according to 4.3.2 of JIS K5701-1.

(4) Comparative Evaluation

[0087] Operations on specimens 3 and 4 were performed using a dispersion apparatus as in Examples 6 and 7 and Comparative Example 6, in which the ratios D1/D2 differed as shown in the following Table 2, and the results were compared. Similarly, operations were performed on each of Example 8 and Comparative Example 8, and the results were compared.
[0088] In Comparative Example 6, flow congestion (flow failure) occurred, and the internal pressure of the dispersion apparatus reached 0.4MPa or more, so that the load increased significantly, and the operation was unable to be continued.

Table 2

	Specimen	Crushing Chamber Capacity (liter)	Shaft Power (kW)	D1: Rotors Outside Diameter (mm)	P: Agitating Members Pitch (mm)	D2: Cylinder Inside Diameter (mm)	D1/P (-)	D1/D2 (-)	Ink Though-put (kg/h)	Dispersion Efficiency	Throughput per Crushing Chamber (kg/h·L)
Example 6	Specimen 3	4.0	12	95	43	150	2.21	0.633	40	--	10.00
Example 7	Specimen 3	4.8	12	74	43	150	1.72	0.493	30	--	6.32
Comparative Example 6	Specimen 3	5.6	15	36	43	150	0.84	0.240	Operation unable	--	--
Example 8	Specimen 4	15.8	24	116	53	220	2.19	0.527	120	1.33	7.59
Comparative Example 8	Specimen 4	20.0	29	50	53	250	0.94	0.227	90	1.00	4.50

[0089] When the examples and comparative examples, which used the same specimens, were each compared and evaluated according to the above Tables 1 and 2, in the case of the examples, the throughput (process capability) to obtain the same quality as the comparative examples was increased by 25 to 40%. In the throughput per single crushing chamber 24 (milling zone), the efficiency was increased by 48 to 96%. Furthermore, the shaft power could be reduced by 10 to 20%, so that an energy saving could be achieved. The throughput per shaft power could be increased by 40 to 85%. In the specimens 1 and 2, the quality (glossiness) of the gravure base ink could be improved along with the improvement of the throughput.

[0090] Moreover, in Examples 6 and 7 in which specimen 3 with high viscosity was used, it was confirmed that high viscosity slurry could be processed acceptably. In Examples 6 and 7, it was confirmed that high viscosity ink, which could not be processed in the conventional apparatus as shown in Comparative Example 6, could be produced stably without causing dispersion failure accompanying bead flow congestion, or internal pressure and shaft power abnormalities due to local over filling of beads.

Effects of the Invention

[0091] Using a dispersion apparatus and a dispersion method according to the present invention described above, a high kinetic energy is given to media around the outer peripheral surface of rotors when rotating, which makes them collide with process material and the like in order to disperse it, and loss of motion can be reduced. Hence the dispersion process of crushing and agitating the process material in the cylinder can be performed efficiently even though the capacity of the cylinder is reduced, enabling the quality of processed material to be improved. Furthermore, no increase in driving force is required for the processing.

[0092] Moreover, in a case where the ratio D1/P of the array pitch P of the agitating members to the outside diameter D1 is set in a range of 1.4 to 3.0, motion of the media in the cylinder is good, so the introduced process materials can be dispersed efficiently and at the same time it is possible to form laminar flow to transport them, so that process efficiency and quality are improved.

Claims

1. A dispersion apparatus (10; 30), in which there are provided rotors (19; 32) in a cylinder (11), and a plurality of agitating members (18) which protrude from said rotors (19; 32) in a radial direction, positioned at a predetermined spacing in a longitudinal direction of the rotors (19; 32), and process material injected into said cylinder (11) is agitated together with media (22) to disperse the process material, wherein the outside diameter of said rotors (19; 32) is D1, the inside diameter of said cylinder (11) is D2, and a ratio D1/D2 is set in a range of 0.4 to 0.7.

2. A dispersion apparatus according to claim 1, wherein where an array pitch of said agitating members (18) is P, a ratio D1/P with the outside diameter D1 of the rotors (19; 32) is set in a range of 1.4 to 3.0.

3. A dispersion apparatus according to claim 1 or 2, wherein there is provided a cooling device (16) in said rotors (19) for cooling the process material.

4. A dispersion apparatus according to any one of claims 1-3, wherein said agitating members (18) are discs.

5. A dispersion apparatus according to any one claims 1-4, wherein said agitating members (18) are discs having slots (21) extending in a radial direction from the outer peripheral surface toward the inside.

6. A dispersion apparatus according to any one of claims 1-5, wherein said agitating members (18) are discs having slots (21) extending in a radial direction from the outer peripheral surface toward the inside, and through holes (23) though which granular media can pass.

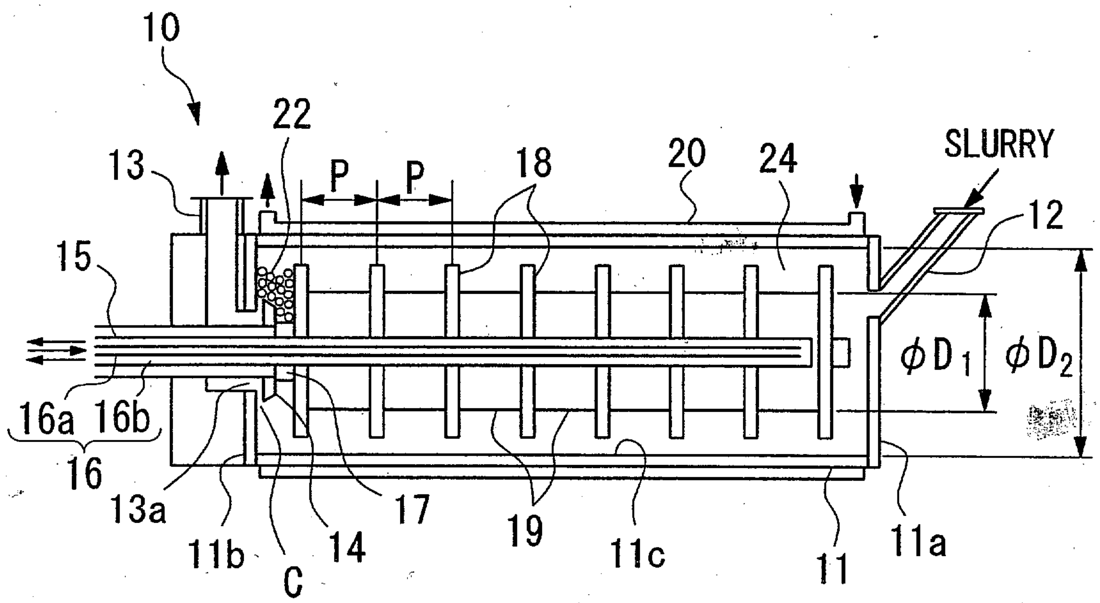
7. A dispersion method, wherein there are provided rotors (19; 32) and agitating members (18) protruding outside of the rotors in a radial direction in a cylinder (11), and an outside diameter of said rotors is D1, an inside diameter of said cylinder (11) is D2, a ratio D1/D2 is set in a range of 0.4 to 0.7, process material is injected into said cylinder (11), and said rotors (19; 32) and agitating members (18) are rotated to agitate said process material together with granular media for the purpose of dispersion processing.

8. A dispersion method according to claim 7, wherein where an array pitch P of said agitating members (18) is P, a ratio D1/P with the outside diameter D1 of the rotors (19; 32) is set in a range of 1.4 to 3.0.

9. A dispersion method according to claim 7 or claim 8, wherein said agitating members (18) are discs having slots (21) extending in a radial direction from the outer peripheral surface toward the inside.

10. A dispersion method according to any one of claims 7-9, wherein said agitating members (18) are discs having slots (21) extending in a radial direction from the outer peripheral surface toward the inside, and through holes (23) through which granular media can pass.

FIG. 1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22
13
P
P
18
20
24
SLURRY
12
15
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ϕD_2
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16b
16
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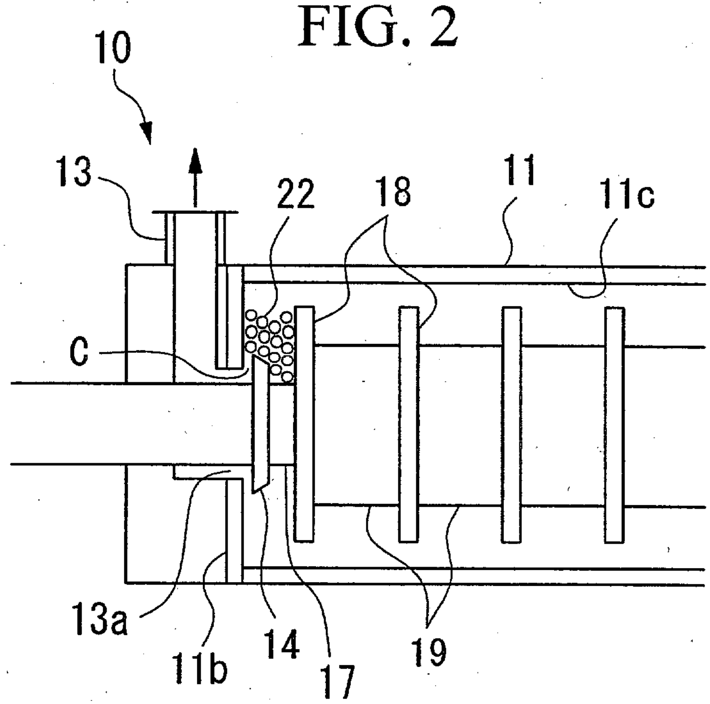
C
14
17
19
11c
11
11a

FIG. 2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13
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19

FIG. 3

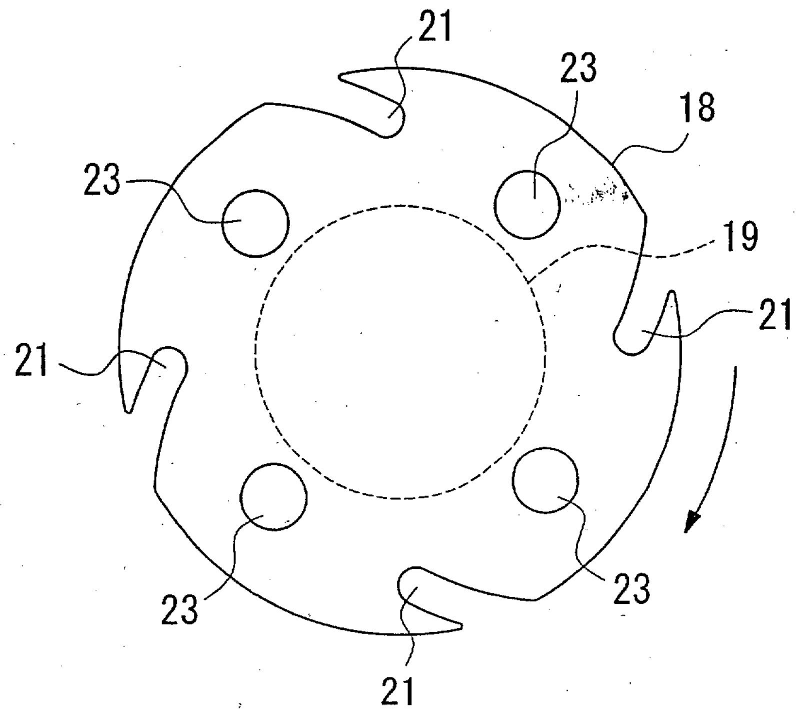


FIG. 4

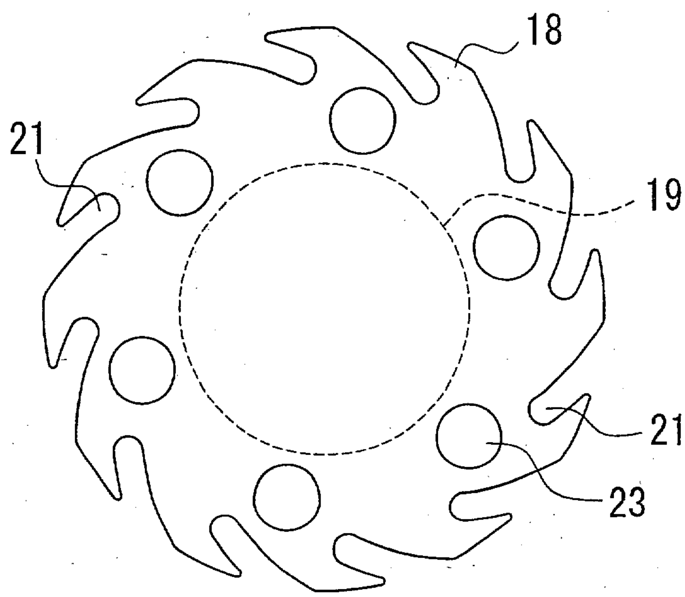


FIG. 5

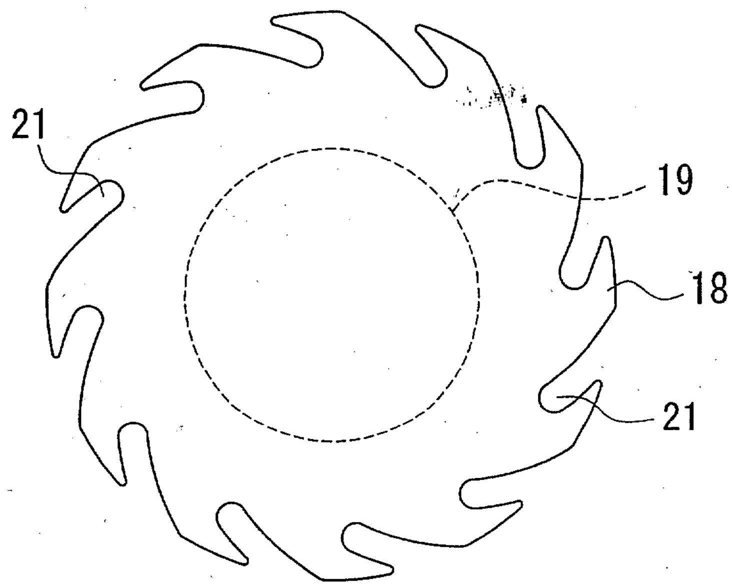


FIG. 6

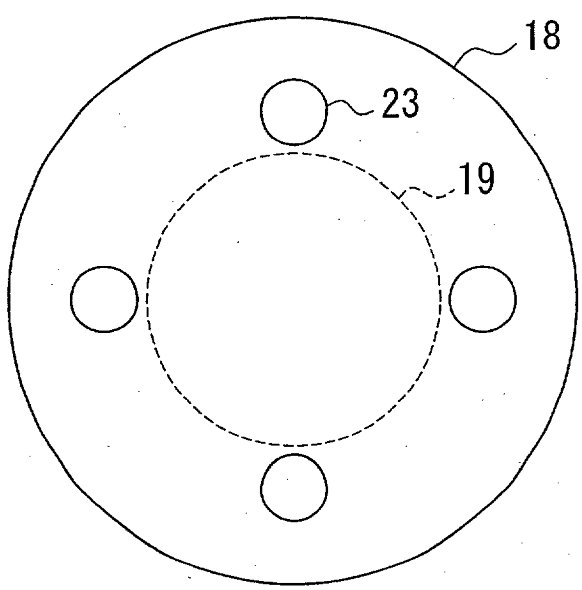


FIG. 7

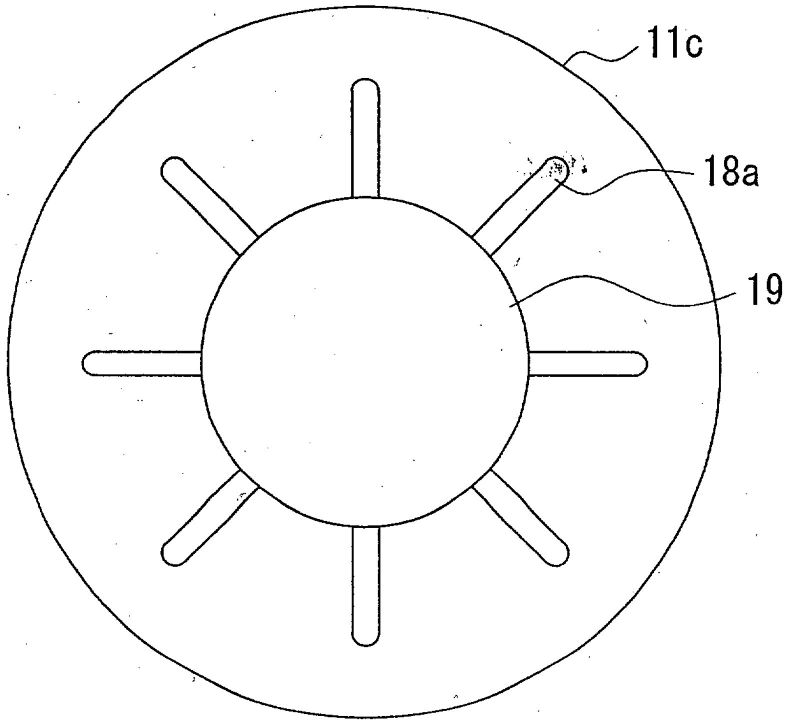


FIG. 8

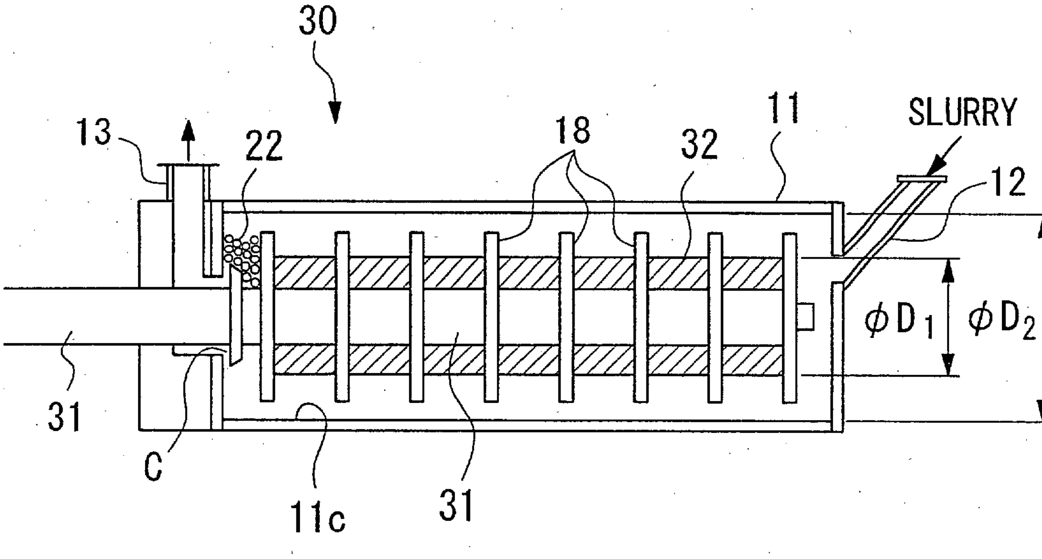


FIG. 9

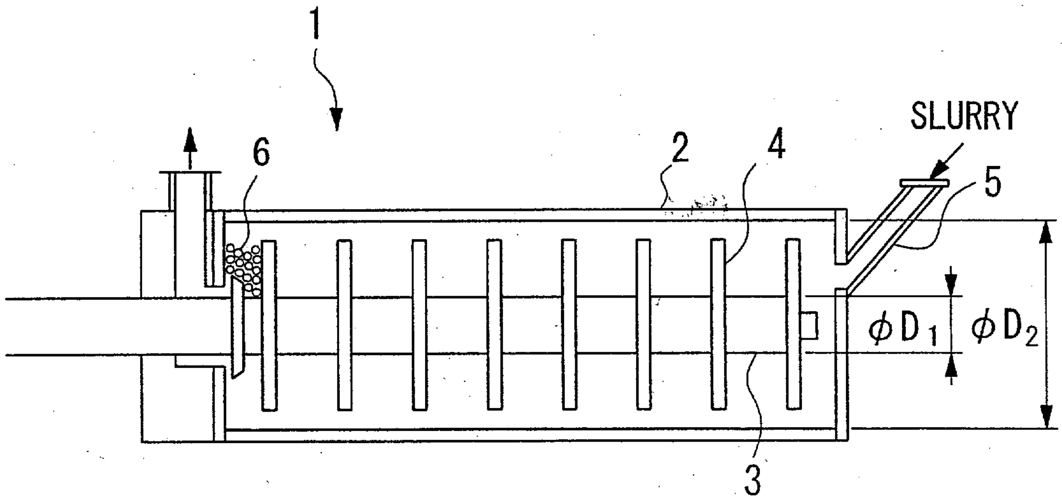
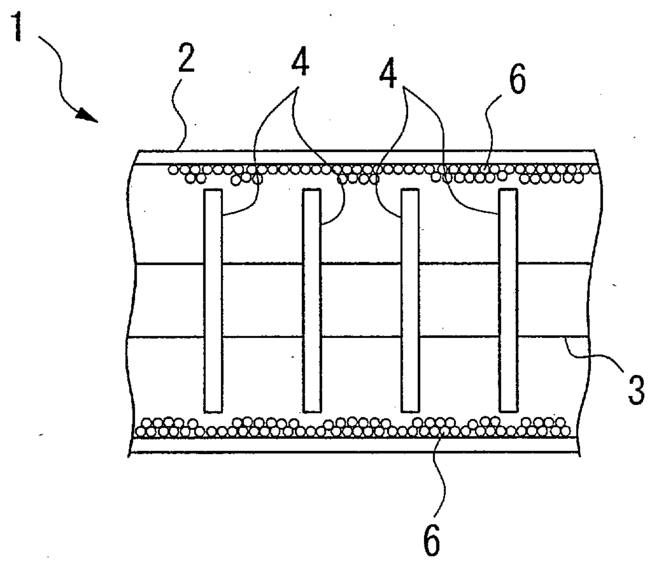


FIG. 10



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EUROPEAN SEARCH REPORT

Application Number
EP 03 00 8822

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	EP 0 704 245 A (MITSUBISHI HEAVY IND LTD) 3 April 1996 (1996-04-03) * column 5, line 47 - line 54 * * column 7, line 22 - column 8, line 3 * * figures 3,10 *	1-3,7,8 4-6,9,10	B02C17/16
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B02C
B01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	11 August 2003	Redelsperger, C

CATEGORY OF CITED DOCUMENTS

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11-08-2003

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