Fig. 1

Fig. 2

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The present invention concerns a vortex type separator for the fractionation of fluids with contents of pulverized solid material of higher specific gravity than the rest of the fluid. Especially the invention relates to separators in which the outflow of the separated heavy fraction is withdrawn from the separator through a discharge chamber of circular cross section. This discharge chamber is formed so that the outflow stream enters or flows through an annular passage around a core piece. This annular passage is bounded externally in its radial direction by the inner side wall of the discharge chamber and internally by a core piece arranged rotatably within the discharge chamber.

Such vortex type separators operate as known in such a way that the input fluid supplied axially to a separating chamber of circular cross section acquires such a rotary motion around the central axis of the chamber that under the influence of centrifugal force the solid material will be concentrated at the radially outer layer of the vortex. When this outer layer, to a greater or lesser extent, is discharged from the separator through the discharge chamber separately from the remainder of the fluid, the solid material will be discharged in this way to a greater or lesser extent. The remainder of the fluid is drawn off from the inner layer of the vortex. The discharge from the outer layer of the vortex is herein referred to as the separated heavy fraction, to distinguish it from the flow from the inner layer of the vortex which is herein referred to as the light fraction. This terminology is especially easy to understand since the solid material often consists of particles of varying weights which generally will be concentrated at varying radial distances from the center of the vortex. The heaviest particles will be concentrated furthest from the center, while the light particles will be concentrated closest to the center. In this way the separated heavy fraction will principally contain the heaviest particles while the light fraction, if the separation is not complete, will contain principally the lightest particles.

This type of separation can be carried out for various purposes, e.g.: (1) For cleaning a fluid which contains relatively small amounts of solid impurities, wherein only a relatively small amount of fluid (the reject) is permitted to flow out in the heavy fraction. Example: Clearing cellulose or paper pulp of mineral components, twigs, etc.

(2) For concentrating the solid components of a fluid, wherein the amount of fluid drawn off with the heavy fraction (the concentrate) may be varied in order to meet different requirements in the degree of concentration. Example: De-watering of cellulose or paper pulp.

(3) For fractionation of solid constituents of various weights of a fluid, wherein the quantity of isolated heavy fraction may be varied to achieve different fraction limits to adapt the process to different fractional distributions. Example: Fractionation of a cellulose fiber slurry into fractions of different fiber sizes.

Thus, the amount of outflow of the heavy fraction must be adapted to each intended separation effect. This adaptation generally occurs by different degrees of constriction of the cross sectional flow area in some particular part of the outlet system, e.g. in the inlet to or the outlet from the discharge chamber. In many cases, however, such a constriction may be incompatible with the size requirement of flow area in order to avoid clogging of the outlet system by the solid components of the heavy fraction. This difficulty occurs in an especially high degree where it is desired to make a single separating system easily adjustable for different separating jobs, and constriction is obtained by using throttle valves which, in most forms, are particularly susceptible to clogging. Special valve embodiments designed to be less susceptible in this respect have been produced precisely for this purpose, but instead they are relatively complicated and expensively constructed.

The present invention aims at eliminating these disadvantages by a simple and economical arrangement wherein the flow of the heavy fraction through the discharge chamber may be controlled without using the above mentioned constriction.

The invention is mainly characterized in that said core piece is arranged eccentrically in the discharge chamber so that the annular passage, seen from an axial direction, extends around the core piece and has a radial width which decreases from a maximum width continuously to a minimum width and thereafter again increases to the maximum width. Also the arrangement includes an outlet from the discharge chamber for the flowing stream which can selectively communicate with the sections of the annular passage having different radial widths.

The invention will be further described below with reference to the accompanying drawings, in which:

FIG. 1 shows a first embodiment of the invention in cross section taken along line I—I in FIG. 2.

FIG. 2 shows the embodiment of FIG. 1 in cross section taken along line II—II in FIG. 1.

FIG. 3 shows a further embodiment of the invention in cross section taken along line III—III in FIG. 4.

FIG. 4 shows the embodiment of FIG. 3 in cross section taken along line IV—IV in FIG. 3.

FIG. 5 shows a modification of a part of the embodiment of FIG. 1 in cross section taken along line II—II in FIG. 1.

FIG. 6 shows the modification according to FIG. 5 in cross section taken along line VI—VI in FIG. 5, and FIG. 7 shows a diagram illustrating the effect achieved by the invention.

Identical details in the various figures are indicated by the same reference symbols. All figures are merely schematic and are only intended as examples without limiting the scope of the invention.

In FIGURES 1 and 2 the bottom part 1 of the separating chamber of a vortex type separator is furnished with a concentrically arranged core piece which consists of a stud 2 extending upward from the bottom of the chamber with a plate 3. Between the inner wall 4 of the separating chamber there is located an annular gap 5. The heavy fraction which is separated against the wall 4 in the separating space above the plate passes through this annular gap to the outlet section located below the plate. This outlet section comprises an annular passage 6 around stud 2. This annular passage has a tangential outlet 7. The stream of the separated heavy fraction acquires a rotary motion in the separating chamber and retains this motion while passing through annular gap 5 and circulating in the annular passage toward outlet 7. Thus it circulates around stud 2 below plate 3 which prevents the separated heavy fraction from returning to the separating space. This arrangement has been disclosed previously in Swedish Patent No. 133,932.

A discharge chamber 8 of circular cross section is connected to outlet 7 through inlet 9. According to the invention this chamber 8 is provided with a stud shaped...
core piece 11 which is eccentrically (with eccentricity E) located with respect to the inner wall 10 of the chamber. When rotated along the axis of the stud 11 (FIG. 2), the annular passage 12 around the eccentrically located stud has a maximum width Wmax, (FIG. 2) and its width decreases continuously to a minimum width Wmin, during half a turn and then increases again to Wmax, during the second half turn. An outlet 13 from the annular passage passes through the core piece from discharge opening 14 in the side wall of this core piece. Core piece 11 extends through the bottom of the discharge chamber and is mounted on this bottom section. The core piece is rotatable around its central axis O1 and may be locked in a selected angular position by means of locknut 15. The axis of wall 10 is denoted by O. In different angular positions opening 14 will be directed toward sections of the annular passage with different widths. In the illustrated position the opening is directed toward the section of minimum width. Starting from the position shown in FIG. 2, if the core piece is rotated clockwise or counter-clockwise it will be successively directed toward wider and wider parts of the annular passage until it comes to the maximum width at 180° from the starting position. If rotation is continued from the 180° position, the effect will, of course, reverse.

Through his own tests the inventor has found that, when a flow, such as the heavy fraction in the present case is passed under substantially constant feed pressure through such a chamber wherein it must rotate around the eccentric core piece, the flow, without undertaking any throttling at the inlet or outlet, will be allowed to pass through in different amounts according to different positions of the core piece, i.e. from sections of different widths of the annular passage.

FIG. 7 illustrates qualitatively the results of a number of tests. The length of line O–a constitutes a measure for comparison. It represents the amount of flow allowed through in the above described initial position, i.e. with opening 14 directed toward the minimum width of the annular passage. The direction of flow in the ring chamber is indicated by arrow R. Measurements carried out in seven other angular positions spaced from each other by about 45° and three comparative lengths O–h, O–g, O–f, O–e, and O–d, respectively. Curve K through points a, b, c, d, e, f, g and h indicates how the passed amount varies continuously with the angular position of the core piece through a complete rotation. It is formed from this curve for example that the minimum amount, approximately O–b, occurred at about 45° and the maximum amount, approximately O–f, occurred when the opening 11 was turned further 180° in the direction of rotation of the flow. The variation in degree of regulation is thus illustrated. The area between K and L represents the region of regulation.

It should be pointed out that FIG. 7 is only intended to illustrate a general trend. For example curve K may vary considerably in form depending on different proportions between the diameter of the flow chamber, the diameter of the core piece, and the eccentricity of the core piece (i.e. D1, D2 and E of FIG. 2). For example an increase of E causes an increase in the region of regulation. Likewise a decrease in E causes a decrease in this region.

The possibility of regulation is due to the different pressures in the circulating flow which occur in the parts of varying width in the chamber. Thus the pressure varies along the circumference of the flow wall of the chamber as well as along the circumference of the core piece. If the discharge opening is turned toward a part of the flow where the pressure is high then naturally a greater amount of flow is withdrawn. Conversely, if the opening is turned toward a low pressure a smaller amount is withdrawn. According to general laws of fluid dynamics the pressure decreases when a fluid flows from a larger to a smaller cross sectional flow area because a part of the pressure is transformed into increased velocity. If the fluid flows in the reverse direction an opposite effect occurs where part of the velocity is converted to pressure. In agreement with this theory the fluid leaving the annular passage is maximum at a relatively wide section and minimum at a relatively narrow section in substantially diametrically opposed sections of the annular passage. The fact that the maximum and minimum amounts are not obtained from exactly maximum and minimum width sections respectively but from widths further along in the direction of the flow of the fluid depends mainly on the character of the circulation of the fluid centrifugal forces arising from this circulation cause the pressure to vary with the radius of the flow so that in each part of the annular passage the pressure is lowest at the core piece and highest at the wall of the chamber. This means that when the outlet opening is placed in the wall of the core piece such as shown in FIGURES 1 and 2 a relatively large opening can be used even for relatively small outlet amounts. This is advantageous in avoiding elongation. It has also been found that due to pressure differences arising from centrifugal force an increase in the diameter of the core piece (and thus the discharge opening will be located at a greater radius regardless of its angular position) causes an increased discharge amount, i.e. both the minimum and maximum amount increase.

In the embodiment according to FIGURES 3 and 4 the conical lower section 1a of the separating chamber of a vortex type separator is furnished with a flange 16 against which an upwardly open casing 17 with a cylindrical internal side wall 18 and bottom 19 is concentrically connected to the outlet 20 of the separating chamber. This core piece 11a differs from core piece 11 only in that it is provided with a plate similar to core piece 2 in FIG. 1 and this plate is turned toward outlet 20. An eccentric ring 21 with circular inner and outer walls is fitted in the casing. This internal wall 10a of the ring is eccentrically located with respect to core piece 11a (with eccentricity E), and encloses a discharge chamber 12a with outlet 14, 13 for the separated heavy fraction. This discharge chamber communicates with the outlet 20 of the separating chamber by means of annular gap 5a. It is obvious that when the heavy fraction, during continuous rotation from the vortex-type separator, flows through gap 5a into discharge chamber 12a, the flow conditions in this chamber around core piece 11a under the plate 3a will be substantially the same as in discharge chamber 12 around core piece 11. Thus it is possible here to control the discharged quantity in the same way by turning core piece 11a about its center line O1. Naturally, the envelope 17 and eccentric ring 18 combination may be replaced by a single part with a chamber 12b eccentric to center line O2, but by using an eccentric ring a further regulation possibility is obtained. The regulation effect is obtained by turning the core piece around its central axis O1 in relation to wall 10a, and obviously the same effect may be obtained instead by turning the eccentric ring, i.e. wall 21, around its central axis O2 in the illustrated embodiment it is necessary to loosen envelope 17 from flange 16 in order to perform this rotation of ring 21, but any one skilled in the art could easily achieve a more convenient rotation arrangement. For example an arm connected to the eccentric ring and passing through a circumferential slit in the envelope for an adjusting screw could be used. By changing eccentric rings one can easily change the eccentricity as well as the diameter of the chamber.

Generally, the embodiment of FIGURES 3 and 4 is
A vortex type separator for the fractionation of fluids containing pulverized solid material, specifically heavier than the rest of the fluid, comprising in combination a discharge chamber of substantially circular cross section for receiving the separated heavy fraction, a core piece of substantially circular cross section eccentrically arranged in said discharge chamber, the space between the inner side wall of said discharge chamber and said core piece providing an annular passage, the radial width of said annular passage around the core piece changing from a maximum width and continuously decreasing to a minimum width and thereafter again increasing to the maximum width, outlet means for said heavy fraction communicating with said discharge chamber and arranged to facilitate the flow of said heavy fraction from said discharge chamber and to cause said heavy fraction to rotate in said annular passage around said core piece, and means to cause said outlet means to communicate selectively with said annular passage at different radial widths thereof.

2. A separator according to claim 1, wherein the outlet means for the separated heavy fraction is in communication with the annular passage around the eccentric core piece in the discharge chamber and extends through said eccentric core piece via a discharge opening in the side wall thereof, and wherein said eccentric core piece is arranged rotatable in relation to the inner side wall of said discharge chamber around an axis adjacent to and substantially parallel to the central axis of said inner side wall so that said discharge opening will face different widths of the annular passage at different turning positions of the eccentric core piece.

3. A separator according to claim 1, wherein the outlet means for the separated heavy fraction is in communication with the annular passage around the eccentric core piece in the discharge chamber and extends through said eccentric core piece via a discharge opening in the side wall thereof, and wherein the inner side wall of said discharge chamber is arranged rotatable in relation to the core piece around an axis adjacent to and substantially parallel to the central axis of said core piece so that said discharge opening will face different widths of the annular passage at different turning positions of said inner side wall.

4. A separator according to claim 1, wherein the outlet means for the separated heavy fraction is in communication with the annular passage around the eccentric core piece in the discharge chamber and extends through the side wall of said discharge chamber and wherein said eccentric core piece is arranged rotatable in relation to said side wall around an axis adjacent to and substantially parallel to its own central axis so that different widths of the annular passage will face said outlet means at different turning positions of the core piece.

No references cited.

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