



Cross-flow separator.

This invention relates to cross-flow separators.

For separating, from a liquid, particles (also comprising other liquid and gas bubbles) suspended therein, cross-flow separators are frequently used.

A cross-flow separator comprises an assembly of plates arranged at mutually equal distances, between which plates passages for passing a liquid to be treated are defined, the flow direction of said liquid being transverse to the direction of largest inclination of said plates, the plates having profiles defining collecting gutters for the components separated from said liquid, and extending substantially in the direction of the greatest inclination. These collecting gutters open into collecting spaces for the separated components.

Currently used cross-flow separators mainly comprise sinusoidally-corrugated plates, the wave amplitude being larger than the average plate spacing. The corrugation crests and troughs respectively are, then, superposed. A consequence of the oscillating movement which the liquid is forced to follow is that the flow velocity at which the liquid changes from the laminar into the turbulent condition is lower than in

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the case of a rectilinear flow in a plate assembly with the same average plate spacing. Moreover, the degree of turbulence will, then, increase faster than in the case of rectilinear flow.

A drawback of such assemblies of corrugated plates is that the streamlined shape of the corrugation crests and troughs will encourage the separated particles to be re-entrained by the liquid, and the capacity of the collecting gutters defined by the corrugations will be small.

The drawback of cross-flow separators with plane plates, which have been known for a longer time, through which the liquid flow is substantially rectilinear, is, however, that the separated particles which can slide downwards along the inclined plates will contact the liquid over the whole plate surface, so that the probability of being entrained again by the liquid will accordingly be higher. It has become apparent that the separation effect of corrugated plates is better than that of plane plates, but, nevertheless, this effect can be still further improved.

According to the present invention there is provided

a cross-flow separator comprising an assembly of equally-spaced, generally parallel plates which plates are inclined to the horizontal, means for introducing contaminated liquids to flow paths between opposed pairs of said plates which flow paths extend in directions transverse to the direction of maximum inclination of the plates, outlet means for removing the treated liquid from said flow paths; each said plate defining gutters extending substantially in the direction of greatest inclination and the gutters of adjacent plates being in opposed relationship, the arrangement being such that the contaminants from the liquid are accumulated in the gutters and collected in collecting spaces communicating with the gutters.

The gutters may be formed by ridges upstanding from the plates which are substantially mutually aligned.

It is also possible to use corrugated plates, the corrugations of adjacent plates being arranged in phase opposition, i.e. so that the gutters lie opposite one another, the corrugations preferably having a substantially trapezoidal cross-section.

For liquids having a low viscosity which do not tend to follow the contour of the gutters, the gutter

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volume, which can be considered as a lost space, will be kept as small as possible. More viscous liquids follow the gutter contour, so that, deeper gutters are preferable so as to screen the separated material, and, at the same time, the velocity of the liquid is reduced.

The invention will now be described, by way of example, with the accompanying diagrammatic drawing, in which:

Fig. 1 is a cross-section of a portion of two plates of a currently available cross-flow separator;

Fig. 2 is a corresponding cross-section of a first embodiment of separate plates according to the invention;

Fig. 3 is a cross-section corresponding to Fig. 2 of slightly modified plates; and

Fig. 4 is a corresponding cross-section of a modification of the plates of Fig. 3 for a high viscosity liquid.

In Fig. 1 portions of two successive corrugated plates 1 and 2 of a cross-flow separator of current construction are shown, in which the liquid flow extends transversely to the generatrices of the corrugations of plates 1 and 2. These corrugations consist of alternating troughs 4 and crests 5 respectively, which, in adjacent plates, always face each other, in other words all corrugations are

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substantially in phase.

Heavier particles sedimentating from the liquid flow 3 collect in the corrugation troughs 4 as indicated at 6, the thickness of the layer of collected particles 6 being dependent upon the velocity at which the particles slide downwards along the inclined plates, and on the supply of particles separated from the liquid. The same applies in the opposite sense for floatating lighter particles which collect, as indicated at 7, beneath the corrugation crests 5.

For liquids having a low viscosity, such as water, it has been found that the transfer velocity at which the flow changes from the laminar into the turbulent condition is considerably lower than in a rectilinear flow, which is caused by the oscillating movement of the flow 3. Behind the corrugation troughs and crests turbulence will be formed even at a low velocity, and, at a further increasing flow velocity, the flow will consist completely of turbulences. As the viscosity increases, also the velocity at which the flow becomes turbulent will increase. The consequence of such turbulence is that the particles collected in the troughs 4 and/or crests 5 will be whirled up and are entrained again, which unfavourably

affects the separation effect of the separator.

Both for liquids with a low as for those with a high viscosity the stream-line shape of the gutters, i.e. the corrugation troughs 4 and crests 5, is unfavourable in as far as the separated particles 6 and 7 are often re-entrained. The thickness of the layer of particles reduces the flow cross-section area, so that the flow velocity near the separated particles is increased, and, therefore, also the probability of turbulences and re-entraining of previously deposited particles. A further draw-back of this corrugation shape is that the capacity for particle retention of the gutters defined by the corrugation crests and troughs is relatively small, and that the surface area of the particle assembly contacting the liquid is relatively large, which also increases the probability of re-entrained particles, in particular by small turbulences which may be generated by friction phenomena at the boundary surface with the flowing liquid.

A rectilinear passage in which some of these drawbacks will be overcome can be obtained, as such, in the simplest manner by means of plane plates which have been known for a long time. Since, however, the



particles sliding downwards along the inclined plates are contacting the flowing liquid over the full plate surface, the probability of already separated particles being entrained is very high. This is the very reason that corrugated plates have been introduced, by means of which the separated components can be kept out of the influence of the flowing liquid as far as possible.

The invention provides an improvement in the known corrugated plate separators in which the main liquid flow can move substantially rectilinearly. In the embodiments of the plates for an improved separator according to the invention shown in the drawing the same reference numerals are used for parts corresponding to parts of Fig. 1.

Fig. 2 shows an embodiment of plates for the case of liquids having a low viscosity, in which a substantially rectilinear flow is obtained, and the separated material remains outside the flow region. Plane plates 1 and 2 are used which are provided at both sides with respective ridges 8 and 9, which are mutually aligned, and also the ridges of adjacent plates are aligned. Thus collecting gutters 4 and 5 are provided which correspond to the crests 4 and



troughs 5 of corrugated plates such as shown in Fig. 1, which gutters, now, in contrast to the case of Fig. 1, are facing each other in pairs at either side of the liquid passage 3. The height of these ridges is such that a sufficiently wide passage 3 for the liquid remains free.

As indicated in Fig. 2, the liquid flow 3 will extend mainly rectilinearly between the extremities of the ridges. At the beginning of the operation, when the gutters have not yet been filled by separated particles, turbulences will develop in these gutters as shown at 10, which turbulences, however, can enhance the separation. As the gutters become filled, these turbulences decrease. The separated particles can also be removed suspended in the liquid, in particular in the case of light flocs.

An advantage of the gutters with square cross-section is, furthermore, that, at corresponding dimensions, their accumulated solids capacity is larger than in the case of sinusoidally corrugated plates of Fig. 1. Since, furthermore, the liquid flow is mainly rectilinear, the flow components directed towards the surface of the accumulated layers 6 and 7, which are present in the oscillating flow according to Fig. 1

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and have a washing-out effect, will be absent.

Fig. 3 shows an embodiment which, fundamentally, corresponds to Fig. 2, in which, however, corrugated plates 1 and 2 are used having corrugations with a trapezoidal cross-section, as in the case of so-called pile planks. Adjacent plates are arranged in phase opposition, so that the gutters 4 and 5 at either side of a liquid passage 3 are always facing each other.

Fig. 4 shows an embodiment corresponding to Fig. 3 but having a longer wave-length and height of the plate corrugations, which embodiment is designed for a liquid with a higher viscosity, e.g. oil. At flow velocities suitable for separation, no turbulences will be generated in the gutters, and the liquid flow will substantially follow the contour of the plate profiles; this is in contrast to liquids with a lower viscosity. It is favourable then to use a longer wave-length and height than in the embodiment of Fig. 3.

As a gutter 4 fills with separated particles 6 (e.g. water droplets), the superposed flow becomes more rectilinear. Since opposite each gutter 4, an inverted gutter 5 is situated which is filled by the

liquid flow, the flow velocity in the central part will become lower, so that the probability of particles being entrained will become smaller accordingly.

A further advantage is that in the constrictions of the flow passage beyond the widened parts at the opposed gutters 4 and 5 a certain flow acceleration will take place again which, as soon as the next widened part of the flow path has been reached, will again change into a deceleration, but can then exert a certain directional effect on the flow.

Instead of the trapezoidally-corrugated plates, plates 1,2 provided with ridges 8,9 of Fig. 2 can be used also for flow conditions envisaged for Fig. 4, and, then, the widths and depths of the gutters will be accordingly increased.

If substantially sinusoidally corrugated plates are used, an improvement of the operation can be obtained if, with a suitable adaptation of the wave-length and height, the plates are arranged in phase opposition.

An example of use of such a cross-flow separator for a liquid with a high viscosity is the treatment of fuel

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oil for marine engines contaminated by water, rust, sand, undesired distillation products (such as asphaltenes) and so on. On board ships centrifuges are currently present which serve to remove such contaminations from the oil. In view of the rising oil prices it is advantageous to use less purified, and therefore cheaper, fuel oil, but this will lead to a rapid deterioration and wear of such centrifuges. A separator according to the invention, in particular according to Fig. 4, can be advantageously used as a pre-separator in which so much contaminant can be removed from the oil that it can be treated thereafter in a centrifuge without detriment to the useful life of the latter.



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CLAIMS

1. A cross-flow separator comprising an assembly of equally-spaced, generally parallel plates which plates are inclined to the horizontal, means for introducing contaminated liquids to flow paths between opposed pairs of said plates which flow paths extend in directions transverse to the direction of maximum inclination of the plates, outlet means for removing the treated liquid from said flow paths; each said plate defining gutters extending substantially in the direction of greatest inclination and the gutters of adjacent plates being in opposed relationship, the arrangement being such that the contaminants from the liquid are accumulated in the gutters and collected in collecting spaces communicating with the gutters.

2. A separator according to claim 1, in which the gutters are defined by ridges which are upstanding from the planes of said of plates, said ridges being provided at both sides of the plates and being substantially aligned with corresponding ridges of adjacent plates.

3. A separator according to claim 1, in which the gutters are formed by corrugations in the plates, the



corrugations in adjacent plates being arranged in phase opposition.

4. A separator according to claim 3, wherein the corrugations have a substantially trapezoidal cross-section.

5. An assembly comprising a separator in accordance with any one of the preceding claims the outlet means of which separator communicates with the inlet of an oil purifying centrifuge.
