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(54) IMPROVEMENTS IN OR RELATING TO A METHOD OF, AND A DEVICE FOR, PROMOTING THE GROWTH OF PARTICLES IN A LIQUID FLOW

(71) We, PIELKENROOD-VINITEK B.V., of 13 Industrieweg, ASSENDELFT, Netherlands, a Dutch Body Corporate, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to the promotion of particle growth in a flowing liquid suspension, prior to separation of the particles from the liquid.

In our Patent Specification No. 1,433,171 there are proposed devices for causing coalescence of particles suspended in a carrier liquid prior to passage of the liquid through a separation device. The coalescence of the particles brings about particle growth and this facilitates the subsequent separation of the particles.

The liquid to be treated is fed through at least one substantially vertical flow duct before being supplied to the separation device at an average flow velocity which is maintained at such a value that substantially all the particles are dragged along in the flow, and particle growth is obtained by coalescence of particles as a consequence of velocity differences between these particles. These velocity differences are, at least partially, a consequence of a transverse velocity gradient in the liquid flow caused by friction against the walls of the flow duct. Also small turbulences will be created which increase the probability of particles meeting one another. The flow duct can be divided into a number of consecutive interconnected and substantially parallel parts with alternating flow sense so as to allow a duct of the desired length to be arranged within a restricted space.

This duct or consecutive parts thereof, is so constructed that the transverse velocity gradient does not become so large that the

shear forces caused thereby and by the related turbulences acting on the coalesced particles will lead to their disruption. In particular, the transverse cross-sectional area in the flow sense may be increased either step-wise or progressively, so that, at a constant flow rate, the linear velocity of the flow decreases and/or the wall distance increases whereby the velocity gradient will be decreased accordingly. By inserting auxiliary partitions extending substantially in the flow direction, the transverse velocity gradient can be increased, and these partitions may be slidable to enable a variation in their effect. As particularly described in Patent Specification No. 1,433,171, the flow duct is defined by arranging substantially vertical partitions in a tank, defining consecutive chambers which are interconnected alternately above and below the partitions.

In this previously proposed device, the flow path is predominantly generally vertical as it was believed that particle growth would only satisfactorily take place along such a path, since when moving along a substantially horizontal duct the separation path length of particles in the direction of gravity towards an adjacent wall is relatively small, so that during passage through such a duct some separation might take place. The separated particles might settle on the duct walls and would, over a long period, lead to a blockage since such a device is not designed as a separator, and, therefore, is not provided with means for continuously removing the separated components.

It has now been found, surprisingly, that satisfactory operation can be obtained when the flow path is directed generally horizontally or is otherwise inclined at a substantial angle to the vertical. It has unexpectedly appeared that the flow velocity in a duct directed in such a manner can be made sufficiently large so as to drag along the particles through the duct without an

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appreciable separation.

According to the present invention, there is provided a method of effecting particle growth in a flowing liquid suspension prior to separation of the grown particles from the liquid in a subsequent stage, wherein the liquid suspension is caused to flow along a path, the average flow rate of the liquid suspension is maintained at such a value that substantially all the particles are dragged along in the flow such that there is substantially no separation of the particles from the liquid, the residence time in this path is such that, as a consequence of differences in the flow velocity of the particles relative to each other in the flow of suspension, particle growth by coalescence is obtained so as to promote the desired separation in the subsequent stage, and the linear flow velocity of the suspension is kept lower than the velocity at which the coalesced particles would be disrupted by shearing action as a consequence of velocity gradients in the flow, a substantial portion of said path being inclined to the vertical by a substantial angle.

Further according to the present invention, there is provided a device having an inlet connected to a supply of the liquid suspension and an outlet connected to an inlet of a separation device, a substantial portion of the duct being inclined to the vertical by a substantial angle, the cross-sectional size of the duct being such that with liquid suspension flow at the design flow rate of the separation device, wall friction will cause differences in the flow velocity of the particles relative to each other in the liquid suspension so that particle growth by coalescence is obtained, and the cross-section of the duct is such that the flow velocity is sufficient to prevent separation of particles in the liquid suspension flow, but is lower than the velocity at which the coalesced particles will be disrupted by a shearing action as a consequence of velocity gradients.

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

Figure 1 shows schematically one embodiment of a particle growth-promoting device according to the invention:

Figure 2 is a fragmentary view of another embodiment of the device; and

Figure 3 shows schematically different methods of positioning the device of Figure 2.

In Figure 1 a section of a particle growth-promoting device according to the invention is shown in a highly simplified manner. This device comprises a vessel 1 with lateral walls 2 and end walls 3. Partitions 4 are provided in the vessel parallel to the end walls 3, and are connected alternately to one or the

other lateral wall 2. In this manner substantially horizontal channels 5 are defined which are interconnected at 6 between an extremity of the partition 5 in question and the adjacent lateral wall 2.

In this manner there is formed a continuous duct through which the direction of flow alternates in opposite directions. One end of the duct communicates with a supply duct 7 for the liquid suspension and the other end with a discharge duct 8. The latter duct 8 is connected to a separator.

The device can be constructed in such a manner that the individual channels 5 are mutually superposed, but it is also possible to juxtapose these channels in another direction.

Because of friction against the partitions 4 the liquid flow will be retarded, so that a transverse velocity gradient will be generated. The particles in a faster liquid flow part will overtake particles in a slightly slower adjacent flow part and, moreover, small turbulences will increase the probability of collision still further, which will lead to coalescence of these particles and, thus, to a considerable particle growth. If, however, it is possible that the larger particles thus obtained will be disrupted again as a consequence of shearing forces between adjacent flow layers with a different velocity, it is preferred to reduce the velocity gradient in the direction of flow. This can be done, as shown, by increasing the distance between the partitions 4 in the flow direction, so that, at a given flow rate, the linear velocity and, thus, the velocity gradient, will be reduced too; also as the distance between the walls becomes greater this will bring about a reduction in the velocity gradient. Additional velocity gradients may be introduced into the flow by providing additional walls in the channels in the flow direction.

Figure 2 shows an embodiment in which, as described in Patent Specification No. 1,485,017 the flow is not fed through a vessel 1 with partitions 4, but, instead, through tubes 9 which are interconnected by means of bend elements 10. These tubes 9 are directed substantially horizontally, and can be superposed or otherwise juxtaposed. The consecutive tubes can have, as considered in the flow sense, an increasing cross-section, the bends then serving as adapting members from one cross-sectional size to the next.

If it is desirable for an economic use of the available space, the channels 5 or tubes 9 can also be superposed obliquely or can be arranged at an angle with respect of the horizontal plane. Figure 3 shows schematically different possibilities, viz. at A in a horizontal plane, and at B in a vertical plane, and at C and D tubes arranged in a sloping plane are shown. Similar possibilities

ties exist in the case of the embodiment of Figure 1.

It will be clear that the number of consecutive chambers 5 or tubes 9 is not restricted to the embodiments shown.

The arrangement described in which the duct is substantially horizontal or is otherwise inclined at a substantial angle to the vertical will permit, in many cases, more favourable utilization of the available space than arrangements in which the duct extends generally vertically.

WHAT WE CLAIM IS:-

1. A method of effecting particle growth in a flowing liquid suspension prior to separation of the grown particles from the liquid in a subsequent stage, wherein the liquid suspension is caused to flow along a path, the average flow rate of the liquid suspension is maintained at such a value that substantially all the particles are dragged along in the flow such that there is substantially no separation of the particles from the liquid, the residence time in this path is such that, as a consequence of differences in the flow velocity of the particles relative to each other in the flow of suspension, particle growth by coalescence is obtained so as to promote the desired separation in the subsequent stage, and the linear flow velocity of the suspension is kept lower than the velocity at which the coalesced particles would be disrupted by shearing action as a consequence of velocity gradients in the flow, a substantial portion of said path being inclined to the vertical by a substantial angle.

2. A method according to claim 1, wherein a substantial portion of said path is substantially horizontal.

3. A method according to claim 1 or claim 2, wherein the flow velocity of the suspension decreases progressively or stepwise in the flow direction.

4. A method according to any one of claims 1 to 3, wherein additional velocity gradients are introduced to the flow to facilitate particle growth.

5. A device for carrying out the method claimed in claim 1, comprising means defining a duct having an inlet connected to a supply of the liquid suspension and an outlet connected to an inlet of a separation device, a substantial portion of the duct being inclined to the vertical by a substantial angle, the cross-sectional size of the duct being such that with liquid suspension flow at the design flow rate of the separation device, wall friction will cause differences in the flow velocity of the particles relative to each other in the liquid suspension so that particle growth by coalescence is obtained, and the cross-section of the duct is such that the flow velocity is sufficient to prevent separation of particles in the liquid suspension flow, but is lower than the velocity at

which the coalesced particles will be disrupted by a shearing action as a consequence of velocity gradients.

6. A device according to claim 5, wherein the duct comprises a plurality of substantially straight portions connected in series and arranged in juxtaposed relation.

7. A device according to claim 5, for carrying out the method as claimed in claim 4, wherein wall means extending in the flow direction are provided in at least part of the duct whereby to introduce additional velocity differences.

8. A method according to claim 1, substantially as hereinbefore described with reference to the accompanying drawing.

9. A device according to claim 5, substantially as hereinbefore described with reference to the accompanying drawing.

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8. A method according to claim 1, substantially as hereinbefore described with reference to the accompanying drawing.

9. A device according to claim 5, substantially as hereinbefore described with reference to the accompanying drawing.

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