METHOD AND DEVICE FOR SEPARATING A LIGHTER DENSITY FLUID FROM A HEAVIER DENSITY FLUID

PRIORITY CLAIM

The present application claims the benefit of U.S. Provisional Application No. 62/733,493, entitled "Method and Device for Removing Bubbles from Liquid," filed September 19, 2018, and U.S. Provisional Application No. 62/873,748, entitled "Method and Device for Separating a Lighter Density Fluid from a Heavier Density Fluid," filed July 12, 2019, both of which are herein incorporated by reference in their entireties.

TECHNICAL FIELD

The present invention relates to separation and removal of a lighter density fluid, such as gas or oil, from a heaver density fluid, and more particularly, to a system which utilizes an impeller and/or a movable extraction pipe to separate and remove a lighter density fluid from a heavier density fluid.

SUMMARY

According to a first aspect of the present disclosure, there is provided a fluid separation apparatus for removing lighter density fluid from a liquid, the fluid separation apparatus including: an annular inlet chamber formed about a central axis and having an inlet in an outer wall of the annular inlet chamber; a first fluid chamber coaxial with the inlet chamber and extending between a first end and a second end, the first fluid chamber having a hollow conical shape with a diameter that reduces between the first end and the second end; a fixed impeller disposed between the annular inlet chamber and the first fluid chamber adjacent the first end of the first fluid chamber, wherein the fixed impeller comprises an outer impeller blade section in fluid communication with the annular inlet chamber adjacent the outer wall of the annular inlet chamber and an inner impeller blade section in fluid communication with the first fluid chamber adjacent a central axis of the first fluid chamber; and an extraction pipe extending within the first fluid chamber from adjacent the first end of the first fluid chamber.

According to a second aspect of the present disclosure, there is provided a fluid separation apparatus for removing lighter density fluid from a liquid, the fluid separation apparatus including: an annular inlet chamber formed about a central axis and having an inlet in an outer wall of the inlet chamber; a first fluid chamber coaxial with the inlet chamber and extending between a first end and a second end, with the first end of the first fluid chamber adjacent the annular inlet chamber, the first fluid chamber having a hollow conical shape with a diameter that reduces between the first end and the second end of the first fluid chamber; an impeller disposed between the inlet chamber and the first fluid chamber adjacent the first end of the first fluid chamber, wherein the impeller comprises a fixed upper shroud, a fixed lower shroud and a plurality of inwardly spiraling fixed impeller blades enclosed by the shrouds and forming a flow path through the impeller, the flow path extending from an inlet at an outer diameter of the upper outer shroud to an outlet at an inner diameter of the lower outer shroud; and an extraction pipe extending within the first fluid chamber adjacent the axis in the first fluid chamber.

According to a third aspect of the present disclosure, there is provided a fluid separation method for removing lighter density fluid from a liquid, the fluid separation method including: introducing a fluid into an annular chamber; circulating the fluid along an inner wall of the annular chamber having a first diameter; directing the fluid circulating at the first diameter into an impeller inlet adjacent the first diameter of a fixed impeller having a fixed upper shroud and a fixed lower shroud enclosing fixed impeller blades; utilizing the fixed impeller blades of the fixed impeller to direct the circulating fluid from the first diameter to a second diameter smaller than the first diameter; releasing the circulating fluid at the smaller diameter into an elongated and conical shaped chamber with a trapezoidal cross-section in a longitudinal direction adjacent a central axis of the chamber; forming an envelope of lighter density fluid around the central axis of the elongated and conical shaped chamber; and positioning a second end which is open of an extraction pipe within the envelope to remove lighter density fluid from the elongated and conical shaped chamber.

According to a fourth aspect of the present disclosure, there is provided a fluid liquid processing apparatus including: a first liquid storage vessel having an outlet; a second liquid storage vessel having an inlet; a first fluid separation apparatus comprising an annular inlet chamber formed about a central axis and having an inlet in an outer wall of the inlet chamber, the inlet in fluid

communication with the outlet of the first liquid storage vessel; a first fluid chamber coaxial with the inlet chamber and extending between a first end adjacent the annular inlet chamber and a second end, the first fluid chamber having a hollow conical shape with a diameter that reduces between the first end and the second end, the inlet of the second liquid storage vessel in fluid communication with the second end of the first fluid chamber; a fixed impeller disposed between the inlet chamber and the first fluid chamber adjacent the first end of the first fluid chamber, wherein the fixed impeller comprises fixed impeller blades that are enclosed between a fixed upper outer shroud and a fixed lower outer shroud to form a flow path through the impeller, the flow path extending from an inlet at an outer diameter of the upper outer shroud and in fluid communication with the annular inlet chamber adjacent the outer wall of the annular inlet chamber to an outlet at an inner diameter of the lower outer shroud and in fluid communication with the first fluid chamber adjacent a central axis of the first fluid chamber; and an extraction pipe extending within the first fluid chamber adjacent the axis in the first fluid chamber.

BRIEF DESCRIPTION OF DRAWINGS

Various embodiments of the present disclosure will be understood more fully from the detailed description given below and from the accompanying drawings of various embodiments of the disclosure. In the drawings, like reference numbers may indicate identical or functionally similar elements.

FIG. 1 is a view showing a fluid system into which a fluid separation apparatus for separation and removal of lighter density fluid from a heavier density fluid.

FIG. 2A is a cross-sectional side view showing an embodiment of a fluid separation apparatus such as shown in FIG. 1.

FIG. 2B is a cross-sectional side view showing another embodiment of a fluid separation apparatus.

FIGS. 3A and 3B are cross-sectional top views of embodiments of a fluid separation apparatus shown in FIG. 1.

end 119. In one or more embodiments, inlet chamber 116 is bowl shaped with an annular chamber gradually increasing in diameter D1 from the first end 117 to the second end 119. In other embodiments, inlet chamber 116 is a cylinder. In some embodiments, the first end 117 may be enclosed and the second end 119 may be open.

An inlet 122 in fluid communication with a main tank 102 is provided in a wall 124 of inlet chamber 116 between the first and second ends 117, 119. As best seen in FIG. 2, while inlet 122 need not be tangentially arranged, in some embodiments inlet 122 is preferably arranged to be generally tangentially positioned in wall 124 so that fluid introduced into inlet chamber 116 flows along the inner surface 125 of wall 124. As shown specifically in FIGS. 3A and 3B, in this regard, the axis or centerline 123 of inlet 122 forms an angle θ with a radial line 127 passing perpendicularly through central axis 115 of inlet chamber 116. As such, the input fluid follows a swirling flow path as it follows the wall 124 around its periphery. Positioned at the second end 119 of inlet chamber 116 is an impeller 130. In one or more embodiments, impeller 130 is fixed relative to inlet chamber 116. Impeller 130 may be attached in the open second end 119 of inlet chamber 116, thereby enclosing inlet chamber 116.

Impeller 130 generally includes an outer impeller blade section 132 in fluid communication with an inner impeller blade section 134. Outer impeller blade section 132 is generally in fluid communication with circular swirling fluid flow of inlet chamber 116 adjacent the periphery of wall 124 at a first impeller diameter DI1. Inner impeller blade section 134 is in fluid communication with first fluid chamber 118 at a second impeller diameter DI2 smaller than the first impeller diameter DI1 so that input fluid flowing into outer impeller blade section 132 from inlet chamber 116 is discharged from inner impeller blade section 134 into first fluid chamber 118 in the swirling-flow tangential direction at second impeller diameter DI2.

The first fluid chamber 118 has a first end 121 and a second end 129 and is formed to have a portion 143 of which is a conical trapezoidal shape with a diameter D2 that gradually reduces between first end 121 and second end 129. A first end 139 of second fluid chamber 120 is in fluid communication with the second end 129 of the first fluid chamber 118, and a second end 141 of the second fluid chamber 120 is connected to the pipe P2 (see FIG. 1). Second end 129 may terminate in an outlet 131.

CLAIMS

1. A fluid separation apparatus for removing lighter density fluid from a liquid, the fluid separation apparatus comprising:

an annular inlet chamber formed about a central axis and having an inlet in an outer wall of the annular inlet chamber;

a first fluid chamber coaxial with the inlet chamber and extending between a first end and a second end, the first fluid chamber having a hollow conical shape with a diameter that reduces between the first end and the second end;

a fixed impeller disposed between the annular inlet chamber and the first fluid chamber adjacent the first end of the first fluid chamber, wherein the fixed impeller comprises an outer impeller blade section in fluid communication with the annular inlet chamber adjacent the outer wall of the annular inlet chamber and an inner impeller blade section in fluid communication with the first fluid chamber adjacent a central axis of the first fluid chamber; and

an extraction pipe extending within the first fluid chamber from adjacent the first end of the first fluid chamber.

2. The fluid separation apparatus of claim 1, wherein the inlet chamber extends from a first end to a second end, which second end is adjacent the first end of the first fluid chamber, wherein the inlet chamber is bowl shaped with the annular chamber gradually increasing in diameter D from the first end to the second end.

3. The fluid separation apparatus of claim 1, wherein the inlet chamber extends from a first end to a second end, which second end is adjacent the first end of the first fluid chamber, wherein the inlet chamber first end is enclosed and the impeller is fixed in the second open end of the annular inlet chamber to enclose the inlet chamber.

4. The fluid separation apparatus of claim 1, wherein the outer impeller blade section and the inner impeller blade section comprise a plurality of impeller blades that are fixed relative to the inlet chamber wall between an upper shroud and a lower shroud together which enclose the plurality of impeller blades.

5. The fluid separation apparatus of claim 1, wherein the inlet of the annular inlet chamber is tangentially offset from the axis of the inlet chamber.

6. The fluid separation apparatus of claim 1, wherein the outer impeller blade section comprises a plurality of inwardly spiraling, spaced apart impeller blades.

7. The fluid separation apparatus of claim 1, wherein the inner impeller blade section comprises a plurality of outwardly spiraling, spaced apart impeller blades extending from an impeller hub.

8. The fluid separation apparatus of claim 1, wherein the outer impeller blade section comprises a plurality of first impeller blades and the inner impeller blade section comprises a plurality of second impeller blades different from the plurality of first impeller blades.

9. The fluid separation apparatus of claim 1, wherein the outer impeller blade section comprises a plurality of fixed first impeller blades and the inner impeller blade section comprises a plurality of fixed second impeller blades, wherein a portion of the plurality of first impeller blades is interleaved with a portion of the plurality of second impeller blades.

10. The fluid separation apparatus of claim 1, wherein a plurality of impeller blades comprise the outer impeller blade section and the inner impeller blade section -and thus form impeller blades extending from a hub of the impeller to adjacent an inner surface of the fluid separation apparatus.

11. The fluid separation apparatus of claim 1, wherein the extraction pipe has a first end and a second end, wherein the first end of the extraction pipe is adjacent the first end of the first fluid chamber and the extraction pipe extends along the axis through the impeller and through the annular inlet chamber, where the extraction pipe has a diameter substantially less than the diameter of first fluid chamber so as to be sufficiently thin or narrow relative to the diameter of the first fluid chamber so as to maintain a lower pressure within the extraction pipe relative to the first fluid chamber.

12. The fluid separation apparatus of claim 11, wherein the second end of the extraction pipe is movable between a first distance from the impeller and a second distance from the impeller.

13. A fluid separation apparatus for removing lighter density fluid from a liquid, the fluid separation apparatus comprising:

an annular inlet chamber formed about a central axis and having an inlet in an outer wall of the inlet chamber;

a first fluid chamber coaxial with the inlet chamber and extending between a first end and a second end, with the first end of the first fluid chamber adjacent the annular inlet chamber, the first fluid chamber having a hollow conical shape with a diameter that reduces between the first end and the second end of the first fluid chamber;

an impeller disposed between the inlet chamber and the first fluid chamber adjacent the first end of the first fluid chamber, wherein the impeller comprises a fixed upper shroud, a fixed lower shroud and a plurality of inwardly spiraling fixed impeller blades enclosed by the shrouds and forming a flow path through the impeller, the flow path extending from an inlet at an outer diameter of the upper outer shroud to an outlet at an inner diameter of the lower outer shroud; and

an extraction pipe extending within the first fluid chamber adjacent the axis in the first fluid chamber.

14. The fluid separation apparatus of claim 13, wherein a second end of the extraction pipe which extends inside the first fluid chamber is movable between a first distance from the impeller and a second distance from the impeller.

15. The fluid separation apparatus of claim 13, wherein the inlet chamber extends from a first end to a second end, which second end is adjacent the first end of the first fluid chamber, wherein the inlet chamber is bowl shaped with the annular chamber gradually increasing in diameter D from the first end to the second end.

16. The fluid separation apparatus of claim 13, wherein the inlet chamber extends from a first end to a second end, which second end is adjacent the first end of the first fluid

chamber, wherein the inlet chamber first end is enclosed and the impeller is fixed in the second end of the annular inlet chamber to enclose the inlet chamber.

17. The fluid separation apparatus of claim 13, wherein the impeller blades, the upper outer shroud, and the lower outer shroud of the impeller are fixed relative to the inlet chamber wall.

18. The fluid separation apparatus of claim 13, wherein the impeller comprises a plurality of impeller blades extending from a hub of the impeller at an inner diameter of the impeller to an outer diameter of the impeller, wherein the impeller blades at the outer diameter of the impeller are adjacent the outer wall of the annular inlet chamber and the impeller blades at the hub of the impeller are adjacent first end of the first fluid chamber.

19. The fluid separation apparatus of claim 13, wherein the extraction pipe has a first end and a second end, wherein the second end of the extraction pipe is adjacent the first end of the first fluid chamber, where the extraction pipe has a diameter substantially less than the diameter of first fluid chamber so as to be sufficiently thin or narrow relative to the diameter of the first fluid chamber so as to maintain a lower pressure within the extraction pipe relative to the first fluid chamber.

20. The fluid separation apparatus of claim 13, further comprising a pressure regulator for applying back pressure to the second end of first fluid chamber.

21. A fluid separation method for removing lighter density fluid from a liquid, the fluid separation method comprising:

introducing a fluid into an annular chamber;

circulating the fluid along an inner wall of the annular chamber having a first diameter;

directing the fluid circulating at the first diameter into an impeller inlet adjacent the first diameter of a fixed impeller having a fixed upper shroud and a fixed lower shroud enclosing fixed impeller blades;

utilizing the fixed impeller blades of the fixed impeller to direct the circulating fluid from the first diameter to a second diameter smaller than the first diameter;

releasing the circulating fluid at the smaller diameter into an elongated and conical shaped chamber with a trapezoidal cross-section in a longitudinal direction adjacent a central axis of the chamber;

forming an envelope of lighter density fluid around the central axis of the elongated and conical shaped chamber; and

positioning a second end which is open of an extraction pipe within the envelope to remove lighter density fluid from the elongated and conical shaped chamber.

22. The fluid separation method of claim 21, further comprising applying back pressure to the elongated and conical shaped chamber and utilizing the back pressure to drive lighter density fluid within the envelope into the extraction pipe.

23. The fluid separation method of claim 21, wherein the step of introducing fluid comprises releasing fluid into the annular chamber tangentially relative to the central axis of the annular chamber and where the extraction pipe has a diameter substantially less than any diameter of elongated and conical shaped chamber so as to be sufficiently thin or narrow relative to the diameter of the elongated and conical shaped chamber so as to maintain a lower pressure within the extraction pipe relative to the elongated and conical shaped chamber.

24. The fluid separation method of claim 21, further comprising circulating liquid from the circulating fluid at the second diameter at a third diameter larger than the lighter density fluid envelope.

25. A liquid processing apparatus comprising

a first liquid storage vessel having an outlet;

a second liquid storage vessel having an inlet;

a first fluid separation apparatus comprising an annular inlet chamber formed about a central axis and having an inlet in an outer wall of the inlet chamber, the inlet in fluid communication with the outlet of the first liquid storage vessel; a first fluid chamber coaxial with the inlet chamber and extending between a first end adjacent the annular inlet chamber and a second end, the first fluid chamber having a hollow conical shape with a diameter that reduces between the first end and the second end,

the inlet of the second liquid storage vessel in fluid communication with the second end of the first fluid chamber;

a fixed impeller disposed between the inlet chamber and the first fluid chamber adjacent the first end of the first fluid chamber, wherein the fixed impeller comprises fixed impeller blades that are enclosed between a fixed upper outer shroud and a fixed lower outer shroud to form a flow path through the impeller, the flow path extending from an inlet at an outer diameter of the upper outer shroud and in fluid communication with the annular inlet chamber adjacent the outer wall of the annular inlet chamber to an outlet at an inner diameter of the lower outer shroud and in fluid communication with the first fluid chamber adjacent a central axis of the first fluid chamber; and

an extraction pipe extending within the first fluid chamber adjacent the axis in the first fluid chamber.

26. The liquid processing system of claim 25, wherein the first liquid storage vessel is a fuel tank and the second liquid storage vessel is a fuel tank.

27. The liquid processing system of claim 26, further comprising a marine vessel on which the second liquid storage tank is carried.

28. The liquid processing system of claim 25, further comprising an internal combustion engine in fluid communication with the second end of the first fluid chamber.

29. The liquid processing system of claim 25, further comprising a processor in fluid communication with the inlet to the annular inlet chamber.

30. The liquid processing system of claim 29, further comprising a solids storage vessel and a solid delivery system communicating between the solids storage vessel and the processor.

31. The liquid processing system of claim 30, wherein the processor is selected from the group consisting of a grinder, a chopper, a crusher, a pulverizer a mixer and a blender.