ABSTRACT

A mixing apparatus for mixing solid in liquid slurry solution is disclosed. The mixing *apparatus includes a tank defining a top surface, a bottom surface and a side surface, and* having an inlet for receiving the solution at or proximate the top surface. A draft tube is vertically arranged within the tank and having an agitator configured to generate a downward flow of the solution. A riser pipe is connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface to act as a first outlet for the solution from the tank. Further, a second outlet is provided for the solution located at or proximate the bottom surface of the tank, such that the riser pipe and the second outlet are disposed on opposite sides of an annular region of the draft tube.

FIG. 1

WE CLAIM:

1. A mixing apparatus for a solid-liquid slurry solution, comprising:

   a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface;

   a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface, the agitator configured to generate a downward flow of the solution towards the second opening of the draft tube;

   a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface, the riser pipe configured as a first outlet for the solution from the tank; and

   a second outlet for the solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

2. The mixing apparatus of claim 1, wherein the riser pipe and the second outlet are oriented at an angle of $180^0 \pm 45^0$ with respect to each other.

3. The mixing apparatus of claim 1, wherein the second outlet is positioned below the second opening of the draft tube.

4. The mixing apparatus of claim 1, wherein the size of the second outlet is same as the riser pipe.

5. The mixing apparatus of claim 1 or 4, wherein the second outlet is configured for 30 to 50 % of the solution flowing out of the tank.

6. The mixing apparatus of claim 1, wherein the tank is a cylindrical vessel.

7. The mixing apparatus of claim 1, wherein the riser pipe and the inlet are disposed on opposite sides of the annular region of the draft tube or 180o ± 90o with respect to each other.

8. The mixing apparatus of claim 1 further comprising a main outlet configured to receive outlet flow from the riser pipe and the second outlet.

2 - DEC 2013

9. The mixing apparatus of claim 1, wherein the solid-liquid slurry solution is a suspension of alumina hydrates in sodium hydroxide.

10. A mixing system for a solid-liquid slurry solution, comprising:

a plurality of mixing apparatuses disposed in fluid communication with each other and configured for continuous flow of solution between them, each mixing apparatus including:

a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface;

a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface, the agitator configured to generate a downward flow of the solution towards the second opening of the draft tube;

a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface, the riser pipe configured as a first outlet for the solution from the tank; and

a second outlet for the solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

11. The mixing system of claim 10, wherein the riser pipe and the second outlet are oriented at an angle of $180^0 \pm 45^0$ with respect to each other.

12. The mixing system of claim 10, wherein the size of the second outlet is same as the riser pipe.

13. The mixing system of claim 10, wherein the second outlet is positioned below the second opening of the draft tube.

14. The mixing system of claim 10 or 13, wherein the second outlet is configured for 30 to 50 % of the solution flowing out of the tank.

15. The mixing system of claim 10, wherein the tank is a cylindrical vessel.

16. The mixing system of claim 10, wherein the riser pipe and the inlet are disposed on opposite sides of the annular region of the draft tube or $180^\circ \pm 90^\circ$ with respect to each other.

2 DEC 2013

17. The mixing system of claim 10 further comprising a main outlet configured to receive outlet flow from the riser pipe and the second outlet.

18. The mixing system of claim 10, wherein the solid-liquid slurry solution is a suspension of *alumina hydrates in sodium hydroxide.*

Dated this 29th day of November 2013

Aparna Kareer
Of Obhan & Associates
Agent for the Applicant
Patent Agent No. 1359

2 DEC 2013

Technical Field:

The present invention relates to a mixing apparatus for a solid-liquid slurry solution, and more particularly to a draft tube circulator capable of continuous operation with improved alumina hydrate suspension.

Background of the Disclosure:

In a batch operation, a conventional circulator having a draft tube and fitted with an axial down pumping impeller/agitator produces a characteristic flow pattern, that is, equal uniform upward flow distribution in the annular region. This uniform upward flow pattern helps to suspend the hydrate particles uniformly in the annular region of the draft tube circulators. It is desired that the circulator provide higher hydrate particle suspension in order to have maximum possible yield of alumina particulates by precipitation. FIG. 2 schematically illustrates the described circulator when used in batch production, showing the flow pattern therein. This non-biased upward annular flow provides a reasonable hydrate particle suspension of approximately close to 85%.

It is known that the batch production inherits certain disadvantages such as low production rate, increase hassle for emptying the tank after every operation cycle, etc. Therefore, it is preferred that such circulators may be operated in a continuous fashion. However, when such a circulator is connected with inlet and outlet launders along for the continuous operation, the flow pattern in the annular region is severely disturbed. It is observed that the draft tube circulator in continuous operation (either in series or in parallel) with or without the riser pipe shows a poor hydrate suspension in the annular region of the draft tube circulator than that of the batch setup.

In draft-tube circulator without a riser pipe, a swirl type flow is observed during continuous operation, wherein the hydrate particle suspension drops close to 78%. In draft-tube circulator with a riser pipe and having a continuous operation, the flow pattern is biased, that is, the flow pattern in an annular region towards the riser pipe is upward and the flow pattern opposite to the riser pipe region is downward. FIG. 3 schematically illustrates such a circulator in continuous operation and shows the flow pattern therein. It may be seen that the upward biased flow in the annular region of the circulators is found to be towards the riser pipe due to the suction happening through the riser pipe and this biased upward flow eventually forces the annular flow in the downward direction in the region opposite to the region installed with the riser pipe. This downward flow pattern in the annular regions pulls down the hydrate particles to settle at a bottom surface, and these solids initiates to gradually pile up at the bottom of the circulator thereafter. As the hydrate built-up height gradually increases, the mean hydrate particle suspension in the continuous flow design for a circulator with the riser pipe is observed to be reduced to below 75%. Further, the build-up may increase the load on an agitator, as the agitator has to force its way through the settled mass below the draft tube.

Methods currently employed in the art that address the aforementioned problem of build-up uses a set up with pipes arranged that extend to the bottom of the mixing vessel. These pipes proceed to extend into the vessel and into the bottom region of the draft tube. Next, pressurized or compressed air is provided or forced through the pipes to agitate and loosen the settled solids. The compressed air enables the liquid to move through solid material and begin to scour away and suspend and/or re-suspend the particles of the settled solids. Other known methods for suspending settled solids in a solid-liquid slurry solution includes using a mixing assembly with an impeller configured to rotate in a first rotational direction for a first period of time and subsequently rotating the impeller in a second rotational direction opposite to the first rotational direction, in order to cause agitation and re-suspension of the hydrates particles in the solution. These previously known solids re-suspension methods and apparatuses have drawbacks such as requiring expensive auxiliary equipment adding to the overall cost, while others require shut-down time for maintenance which also adds costs to the operation of the mixing vessel.

Therefore, there is a need of providing an apparatus for correcting the biased downward directed annular flow pattern or altering the downward directed annular flow to annular upward directed flow pattern in the region opposite to the riser pipe zone. This may improve the overall particle suspension and ultimately will help in improving the particle stabilization and improved suspension in the entire equipment.

Summary:

The present invention relates to a mixing apparatus for a solid-liquid slurry solution including a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface. The mixing apparatus includes a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface. The agitator is configured to generate a downward flow of the solution towards the second opening of the draft tube. The mixing apparatus also includes a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface. The riser pipe is configured as a first outlet for the solution from the tank. Further, the mixing apparatus includes a second outlet for the

solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

The present invention also relates to a mixing system for a solid-liquid slurry solution *including a plurality of mixing apparatuses disposed in fluid communication with each other* and configured for continuous flow of solution between them. Each of the mixing apparatus includes a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface. The mixing apparatus includes a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface. The agitator is configured to generate a downward flow of the solution towards the second opening of the draft tube. The mixing apparatus also includes a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface. The riser pipe is configured as a first outlet for the solution from the tank. Further, the mixing apparatus includes a second outlet for the solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

Brief Description of Drawings:

FIG. 1 illustrates a schematic representation of a mixing apparatus in accordance with an embodiment of the present disclosure;

FIG. 2 illustrates a schematic representation of a conventional draft-tube circulator showing the flow profile in batch operation;

FIG. 3 illustrates a schematic representation of a conventional draft-tube circulator showing the flow profile in continuous operation;

FIG. 4 illustrates a schematic representation of a mixing apparatus in accordance with an embodiment of the present disclosure showing the flow profile in continuous operation;

FIG. 5 illustrates a schematic representation of a mixing system in accordance with an embodiment of the present disclosure; and

FIG. 6 depicts a plot showing a comparison of the hydrate particle suspension in a solid-liquid slurry solution for different mixing apparatuses.

Detailed Description:

As required, a schematic, exemplary embodiment of the present fixture is disclosed herein; however, it is to be understood that the disclosed embodiment is merely exemplary of the present disclosure, which may be embodied in various and / or alternative forms. Specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present disclosure in virtually any appropriately detailed structure.

For the purpose of illustration, numerals referring to FIG. 2 will carry an apostrophe ['] and numerals referring to FIG. 3 will carry a quote mark ["], while still representing the same physical feature as represented in FIG. 1.

Various preferred embodiments of the present invention relate to a mixing apparatus for a solid-liquid slurry solution to provide for a re-suspension of settled solids, such as alumina or alumina hydrates, in mixing systems or the like. It should be understood, however, that the present invention is not limited in its application to mixing systems or the suspension of alumina or alumina hydrates, but, for example, may be used with other processes and/or apparatuses requiring the suspension or re-suspension of solids. Further, hereinafter the terms "solid-liquid slurry solution" may be simply referred to as "solution". The mixing apparatus of the present invention is preferably a draft-tube circulator, and hereinafter the terms are interchangeably used for the purpose of this disclosure. Preferred embodiments of the invention will now be further described with reference to the accompanied figures.

Referring now to FIG. 1, a mixing apparatus, generally designated as 100, is depicted for mixing a liquid in which a solid material is suspended. The mixing apparatus 100 includes a tank 102 defining a top surface 104, a bottom surface 106 and a side surface 108. In a preferred embodiment, the tank 102 may be a cylindrical vessel. However, in other embodiments, the tank 102 may be of some other suitable shape according to the purpose. The tank 102 includes an inlet 110, for receiving the solution in the mixing apparatus 100, provided at or proximate the top surface 104. In an embodiment, the inlet 110 may be disposed at the side surface 108 therein.

The mixing apparatus 100 further includes a draft tube 112 vertically arranged at a central location within the tank 102. The draft tube 112 defines an annular region inside the tank 102. The draft tube 112 includes a first opening 114 proximate the top surface 104 and a second opening 116 proximate the bottom surface 106. The mixing apparatus 100 also includes an agitator 118 mounted inside the draft tube 112, preferably near the first opening 114 of the draft tube 112. As illustrated in FIG. 1, the agitator 118 may be connected to a rotatable shaft 120 which in turn connected to a gear drive (not shown) which is driven by a motor (not shown). The agitator 118 may be configured to generate a downward flow of the solid-liquid slurry solution in a direction from the first opening 114 towards the second opening 116 of the draft tube 112.

As illustrated in FIG. 1, the draft tube 112 may be supported in the tank 102 by means of support members 122. Such an arrangement defines a free-board region 124 below the draft tube 112 inside the tank 102 of the mixing apparatus 100. The mixing apparatus 100 may further include vanes 126 connected to the draft tube 112. As illustrated in FIG. 1, the vanes 126 are positioned immediately below and downstream of the agitator 118 of inside the draft tube 112. The vanes 126 may be configured to guide the liquid material downward from the agitator 118 while simultaneously reducing the likelihood of swirling of the slurry solution inside the draft tube 112 and above the slot region 127. The slot region 127 is located near the second opening 116 of the draft tube 112.

The mixing apparatus 100 also includes a riser pipe 128 provided within the tank 102. The riser pipe 128 may be connected at a point at or proximate the top surface 104 and extending within the tank 102 towards the bottom surface 106. In a preferred embodiment, the riser pipe 128 may be vertically arranged in parallel and close proximity to the side surface 108 inside the tank 102. The riser pipe 128 may be connected at other end with means for providing suction, such as a any sort of suction pump or flow by potential head difference (not shown) for withdrawal of solution from the tank 102. The riser pipe 128 may be configured as a first outlet 130 for the solution from the tank 102. It may be seen that the riser pipe 128 and the inlet 110 are disposed on opposite sides of the annular region of the draft tube 112 or $180^{\circ} \pm 90^{\circ}$ with respect to each other.

The mixing apparatus 100 further includes a second outlet 132 for the solution inside the tank 102. The second outlet 132 may be located at or proximate the bottom surface 106 of the tank 102. The second outlet 132 may be connected at other end with means for *providing suction, such as any sort of suction pump for withdrawal of solution from the tank* 102. In accordance with an embodiment of the present invention, the riser pipe 128 and the second outlet 132 may be disposed on opposite sides of the annular region defined by the draft tube 112 in relation to the side surface 108. Further as could be seen from FIG. 1, the riser pipe 128 and the second outlet 132 are oriented at an angle of $180^{0} \pm 45^{0}$ with respect to each other. That is, the second outlet 132 is disposed diametrically opposite at an angle in the range of $\pm 45^{0}$ with respect to the riser pipe 128. In an embodiment, the size of the second outlet 132 is approximately same as that of the riser pipe 128. In a preferred embodiment, the second outlet 132 is positioned below the second opening 116 of the draft tube 112 inside the tank 102.

It may be understood by a person ordinarily skilled in the art that the first outlet 130 and the second outlet 132 may be responsible for outflow of the solution from the tank 102 of the mixing apparatus 100. In a further embodiment of the present invention, the second outlet 132 may be configured for 30 to 50 % of the solution flowing out of the tank 102 or the *average velocity levels in the riser pipe 128 and second outlet 132 may be equivalent*. This may be achieved by providing different suction rates at the two outlets 130, 132 by means of using any sort of suction pumps.

In an embodiment, as illustrated in FIG. 5, the present invention also provides a mixing system 10 for a solid-liquid slurry solution. FIG. 5 illustrates the mixing system 10 showing the circuit flow profile in continuous operation. The directional arrows depict the flow of the solution outside the tank in the flow circuit along with the additional second outlet 132 of the present disclosure. The mixing system 10 may include a plurality of mixing apparatuses 100, 200, as disclosed above, working in continuous operation. For the purpose of illustration, FIG. 5 of the present disclosure only shows two such mixing apparatuses 100, 200 connected in series. However, it may be contemplated that more than two apparatuses may be provided for the mixing system 10. The various mixing apparatuses 100, 200 are in fluid communication with each other, such that the outflow of one of the mixing apparatus, for example 200, is fed to the inlet 110 of the next mixing apparatus 100 in the present mixing system 10. According to an embodiment, each of the mixing apparatuses 100, 200 may also include a main outlet 134 configured to receive the outward flow from the riser pipe 128 as well as the second outlet 132. It is this combined outflow from the main outlet 134 of the mixing apparatus 200 that may be passed to the next mixing apparatus 100. The arrangement as shown in FIG. 5 allows for continuous operation of the mixing system 10.

Specific Embodiments are described below:

A mixing apparatus for a solid-liquid slurry solution, comprising a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface, a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface, the agitator configured to generate a downward flow of the solution towards the second opening of the draft tube, a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface, the riser pipe configured as a first outlet for the solution from the tank, and a second outlet for the solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

Such mixing apparatus, wherein the riser pipe and the second outlet are oriented at an angle of $180^0 \pm 45^0$ with respect to each other.

Such mixing apparatus, wherein the second outlet is positioned below the second opening of the draft tube.

Such mixing apparatus, wherein the size of the second outlet is same as the riser pipe.

Such mixing apparatus, wherein the second outlet is configured for 30 to 50 % of the solution flowing out of the tank.

Such mixing apparatus, wherein the tank is a cylindrical vessel.

Such mixing apparatus, wherein the riser pipe and the inlet are disposed on opposite sides of the annular region of the draft tube or 180o ± 90o with respect to each other.

Such mixing apparatus further comprising a main outlet configured to receive outlet flow from the riser pipe and the second outlet.

Such mixing apparatus, wherein the solid-liquid slurry solution is a suspension of alumina hydrates in sodium hydroxide.

Further specific embodiments are described below:

A mixing system for a solid-liquid slurry solution, comprising a plurality of mixing apparatuses disposed in fluid communication with each other and configured for continuous flow of solution between them, each mixing apparatus including a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface, a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface, the agitator configured to generate a downward flow of the solution towards the second opening of the draft tube, a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface, the riser pipe configured as a first outlet for the solution from the tank; and a second outlet for the solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

Such mixing system, wherein the riser pipe and the second outlet are oriented at an angle of $180^0 \pm 45^0$ with respect to each other.

Such mixing system, wherein the size of the second outlet is same as the riser pipe.

Such mixing system, wherein the second outlet is positioned below the second opening of the draft tube.

Such mixing system, wherein the second outlet is configured for 30 to 50 % of the solution flowing out of the tank.

Such mixing system, wherein the tank is a cylindrical vessel.

Such mixing system, wherein the riser pipe and the inlet are disposed on opposite sides of the annular region of the draft tube or $180^\circ \pm 90^\circ$ with respect to each other.

Such mixing system further comprising a main outlet configured to receive outlet flow from the riser pipe and the second outlet.

Such mixing system, wherein the solid-liquid slurry solution is a suspension of alumina hydrates in sodium hydroxide.

Industrial Applicability:

The present invention relates to the additional outlet, that is, the second outlet 132 for improved non-biased upward flow in the annular region of the draft tube 112 of the mixing apparatus 100. The invention particularly allows for continuous operation of the mixing apparatuses 100, 200 placed in connection in a mixing system 10, while maintaining a reasonable hydrate particle suspension in the solution.

For example, for a solution of alumina hydrate with sodium hydroxide (commonly known as caustic soda), it has been observed that the conventional draft tube circulators with riser pipe and having a continuous operation results in settling of hydrate particulates during the course of the operation, with the hydrate particle suspension dropping approximately to less than 75% as compared to close to 85 % in case of batch production process. With the second outlet 132 of the present invention, the mean hydrate particle suspension in the continuous flow design with riser pipe increases to be around 85%. Due to the improved hydrate suspension, the effective processing volume and retention time of the equipment increases which will improve the precipitation yield and quality of the precipitated hydrate particles in terms of its shape and size.

FIG. 4 illustrates the mixing apparatus 100 showing the flow profile in continuous operation. The directional arrows depict the flow of the solution inside the tank in the mixing apparatus 100 with the additional second outlet 132 of the present disclosure. Such mixing apparatus 100 alters the biased downward flow in the annular region with the riser pipe 128" (as seen from FIG. 3) to the non-biased upward flow in the same region (as could be seen from FIG. 4) at the second opening of 116 of the draft tube 112. This upward flow thrusts the settled hydrate particles in the free-board region to move upwards and re-suspend within the solution in the annular region, and therefore provides an improved hydrate particle suspension.

The new additional second outlet 132 for the continuous operation provides the following advantages. (i) Alters the biased downward annular flow to a non-biased uniform axial upflow in the annular region. (ii) Further, the additional suction location increases the velocity levels in the bottom of the tank such that it helps to keep the particles in suspension in the free board region.

A comparison of the hydrate particle suspension trend is plotted in the accompanied FIG. 6 and represented in Table 1. The zero value in the x-axis represents the location of the hub of the impeller/agitator and the negative values are the distance below the impeller/agitator and the positive values is the distance above the impeller/agitator.

Mixing Apparatus Design	**Conventional Mixing Apparatus for Batch Operation (FIG. 2.)**	**Conventional Mixing Apparatus for Continuous Operation (FIG. 3.)**	**Mixing Apparatus with Second Outlet for Continuous Operation (FIG. 4.)**
Mean Hydrate Particle Suspension (%)	84.68	76.59	84.96

Table 1 showing the comparison of the hydrate particle suspension in a solution for different mixing apparatuses.

WE CLAIM:

1. A mixing apparatus for a solid-liquid slurry solution, comprising:

   a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface;

   a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface, the agitator configured to generate a downward flow of the solution towards the second opening of the draft tube;

   a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface, the riser pipe configured as a first outlet for the solution from the tank; and

   a second outlet for the solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

2. The mixing apparatus of claim 1, wherein the riser pipe and the second outlet are oriented at an angle of $180^0 \pm 45^0$ with respect to each other.

3. The mixing apparatus of claim 1, wherein the second outlet is positioned below the second opening of the draft tube.

4. The mixing apparatus of claim 1, wherein the size of the second outlet is same as the riser pipe.

5. The mixing apparatus of claim 1 or 4, wherein the second outlet is configured for 30 to 50 % of the solution flowing out of the tank.

6. The mixing apparatus of claim 1, wherein the tank is a cylindrical vessel.

7. The mixing apparatus of claim 1, wherein the riser pipe and the inlet are disposed on opposite sides of the annular region of the draft tube or 180o ± 90o with respect to each other.

8. The mixing apparatus of claim 1 further comprising a main outlet configured to receive outlet flow from the riser pipe and the second outlet.

2 - DEC 2013

9. The mixing apparatus of claim 1, wherein the solid-liquid slurry solution is a suspension of alumina hydrates in sodium hydroxide.

10. A mixing system for a solid-liquid slurry solution, comprising:

a plurality of mixing apparatuses disposed in fluid communication with each other and configured for continuous flow of solution between them, each mixing apparatus including:

a tank defining a top surface, a bottom surface and a side surface and having an inlet for receiving the solution at or proximate the top surface;

a draft tube vertically arranged within the tank and having an agitator axially mounted therein, the draft tube defining a first opening proximate the top surface and a second opening proximate the bottom surface, the agitator configured to generate a downward flow of the solution towards the second opening of the draft tube;

a riser pipe connected to the tank at a point at or proximate the top surface and extending within the tank towards the bottom surface, the riser pipe configured as a first outlet for the solution from the tank; and

a second outlet for the solution located at or proximate the bottom surface of the tank, the riser pipe and the second outlet disposed on opposite sides of annular region of the draft tube.

11. The mixing system of claim 10, wherein the riser pipe and the second outlet are oriented at an angle of $180^0 \pm 45^0$ with respect to each other.

12. The mixing system of claim 10, wherein the size of the second outlet is same as the riser pipe.

13. The mixing system of claim 10, wherein the second outlet is positioned below the second opening of the draft tube.

14. The mixing system of claim 10 or 13, wherein the second outlet is configured for 30 to 50 % of the solution flowing out of the tank.

15. The mixing system of claim 10, wherein the tank is a cylindrical vessel.

16. The mixing system of claim 10, wherein the riser pipe and the inlet are disposed on opposite sides of the annular region of the draft tube or $180^\circ \pm 90^\circ$ with respect to each other.

17. The mixing system of claim 10 further comprising a main outlet configured to receive outlet flow from the riser pipe and the second outlet.

18. The mixing system of claim 10, wherein the solid-liquid slurry solution is a suspension of alumina hydrates in sodium hydroxide.

Dated this 29th day of November 2013

Aparna Kareer
Of Obhan & Associates
Agent for the Applicant
Patent Agent No. 1359