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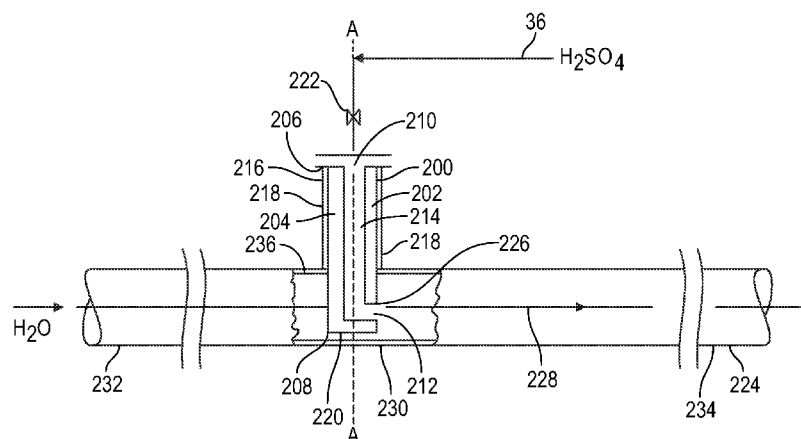
(54) **Title:** INLET NOZZLE FOR ACID ADDITION

FIG. 2

(57) **Abstract:** An inlet nozzle comprises an elongated cylinder. The elongated cylinder includes a polymer extending between first end and second ends of the elongated cylinder. The first end defines an inlet opening and a second end defines an outlet opening. A channel is in fluid communication with the inlet opening and the outlet opening. At least a portion of the elongated cylinder is encased in a metal. The elongated cylinder may be used in combination with a conduit that conveys a process stream. The nozzle is configured to convey acid through the outlet opening and into the conduit in the same direction as the direction of the process stream flowing through the conduit.

INLET NOZZLE FOR ACID ADDITION

FIELD OF THE INVENTION

- [1] Apparatuses and processes are provided for providing an acid to an aqueous stream. More specifically, an inlet nozzle is provided that combines polymer and metal for enhanced corrosion resistance.

BACKGROUND

- [2] A number of industrial processes utilize addition of acid to an aqueous stream. For example, acrylonitrile is an important commodity chemical used mainly as monomer for the manufacture of a wide variety of polymeric materials such as polymers for acrylic fibers used in textiles, and in resins such as ABS and SAN resins. Worldwide, acrylonitrile is produced in amounts exceeding four million metric tons per year. The most commonly used process for manufacturing acrylonitrile or other olefinically unsaturated nitrile, such as methacrylonitrile, is to react a suitable hydrocarbon, such as propylene or propane for the manufacture of acrylonitrile, or isobutylene for the manufacture of methacrylonitrile, in an ammoxidation reactor in the presence of ammonia using air or other source of molecular oxygen as an oxidant. Such oxidation reactions, also called ammoxidation reactions, typically use a solid, particulate, heterogeneous catalyst in a fluidized catalyst bed to catalyze the ammoxidation reaction and provide the desired acrylonitrile or methacrylonitrile in acceptable conversion and yield. In addition to producing an olefinically unsaturated nitrile, such ammoxidation reactions also generally produce other products such as acetonitrile, hydrogen cyanide (HCN) and other co-products. Processes for the catalytic ammoxidation of a hydrocarbon feed to acrylonitrile are disclosed, for example, in U.S. Pat. Nos. 4,503,001; 4,767,878; 4,863,891 and 5,093,299, all of which are incorporated herein by reference.
- [3] The processes widely used in commercial practice for recovering the products of such hydrocarbon ammoxidation, such as the ammoxidation of propylene to form acrylonitrile, generally comprise the steps of: a) contacting the effluent from an ammoxidation reactor in a quench tower or column with an aqueous quench liquid to cool the gaseous effluent; b) contacting the quenched gaseous effluent with water in an absorber, forming an aqueous solution comprising the ammoxidation products; c)

subjecting the aqueous solution to a water extractive distillation in a distillation column, and d) removing a first overhead vapor stream comprising the unsaturated nitrile and some water from the top of the column, and collecting a liquid waste stream containing water and contaminants from the bottom of the column. Further purification of the olefinically unsaturated nitrile, such as acrylonitrile, may be accomplished by passing the overhead vapor stream to a second distillation column to remove at least some impurities from the acrylonitrile, and further distilling the partially purified acrylonitrile. The effluent from the ammoxidation reactor generally contains a certain amount of ammonia. Therefore, the quench liquid used in the quench column may also contain a strong mineral acid, such as sulfuric acid, to react with and thereby form a water soluble salt of ammonia, such as ammonium sulfate. The used or spent quench fluid containing the ammonium sulfate and other components is typically treated or disposed of in an environmentally safe manner.

- [4] While the manufacture of acrylonitrile/methacrylonitrile has been commercially practiced for years there are still areas in which improvement would have a substantial benefit. Aqueous quench liquid is typically conveyed to the quench column through a quench liquid conduit comprising an alloy. Strong acid is typically added to the quench liquid conduit and is carried along with and mixes with the water flowing through this conduit to the quench column. The addition of a strong acid to water to form the quench liquid conveyed to the quench column may result in a localized zone of sulfuric acid that is highly corrosive, particularly at or near the location where the acid is introduced into the conduit. An area of improvement would be improved delivery of the acid to water to form the quench liquid with reduced corrosion.

SUMMARY

- [5] Accordingly, an aspect of the disclosure is to provide a safe, effective and cost effective process and apparatus that overcomes or reduces the disadvantages of conventional processes and apparatuses.
- [6] An inlet nozzle includes an elongated polymer cylinder having a first end defining an inlet opening and a second end. The nozzle includes a channel within the elongated polymer cylinder, the channel being effective for providing fluid communication

between the inlet opening and the outlet opening. In one aspect, a metal encases at least a portion of the elongated polymer cylinder. In another aspect, the metal is spaced about 0 to about 50 times a diameter of the outlet opening away from the outlet opening.

- [7] In another aspect, an inlet conduit includes an inner polymer sleeve and an outer metal sleeve. The inner polymer sleeve includes a first end defining an inlet opening and a second end defining an outlet opening and the outer sleeve defines a first end and a second end. In one aspect, the second end of the polymer sleeve extends about 0 to about 50 times a diameter of the outlet opening beyond the outer metal sleeve.
- [8] In another aspect, a process for providing acid to a process stream includes supplying acid through an inlet nozzle to a process stream. The inlet nozzle includes an elongated polymer cylinder having a first end defining an inlet opening and a second end. The nozzle includes a channel within the elongated polymer cylinder, the channel being effective for providing fluid communication between the inlet opening and the outlet opening. In one aspect, a metal encases at least a portion of the elongated polymer cylinder. In another aspect, the metal is spaced about 0 to about 50 times a diameter of the outlet opening away from the outlet opening.
- [9] In another aspect, a process for providing acid to a process stream includes supplying acid through an inlet conduit to a process stream. The inlet conduit includes an inner polymer sleeve and an outer metal sleeve. The inner polymer sleeve includes a first end defining an inlet opening and a second end defining an outlet opening and the outer sleeve defines a first end and a second end. In one aspect, the second end of the polymer sleeve extending about 0 to about 50 times a diameter of the outlet opening beyond the outer metal sleeve.
- [10] In another aspect, an acid addition system includes a process stream conduit and an inlet nozzle extending into the process stream conduit. The inlet nozzle includes an elongated polymer cylinder having a first end defining an inlet opening and a second end. The nozzle includes a channel within the elongated polymer cylinder, the channel being effective for providing fluid communication between the inlet opening and the outlet opening. In one aspect, a metal encases at least a portion of the

elongated polymer cylinder. In another aspect, the metal is spaced about 0 to about 50 times a diameter of the outlet opening away from the outlet opening.

- [11] In another aspect, an acid addition system includes a process stream conduit and an acid inlet conduit extending into the process stream conduit. The inlet conduit includes an inner polymer sleeve and an outer metal sleeve. The inner polymer sleeve includes a first end defining an inlet opening and a second end defining an outlet opening and the outer sleeve defines a first end and a second end. In one aspect, the second end of the polymer sleeve extends about 0 to about 50 times a diameter of the outlet opening beyond the outer metal sleeve.
- [12] In another aspect, an apparatus includes a reactor vessel configured to receive an aqueous stream and an acid inlet nozzle configured to provide acid to the aqueous stream. The inlet nozzle includes an elongated polymer cylinder having a first end defining an inlet opening and a second end. The nozzle includes a channel within the elongated polymer cylinder, the channel being effective for providing fluid communication between the inlet opening and the outlet opening. In one aspect, a metal encases at least a portion of the elongated polymer cylinder. In another aspect, the metal is spaced about 0 to about 50 times a diameter of the outlet opening away from the outlet opening.
- [13] In another aspect, an apparatus includes a reactor vessel configured to receive an aqueous stream and an inlet conduit configured to provide acid to the aqueous stream. The inlet conduit includes an inner polymer sleeve and an outer metal sleeve. The inner polymer sleeve includes a first end defining an inlet opening and a second end defining an outlet opening and the outer sleeve defines a first end and a second end. In one aspect, the second end of the polymer sleeve extends about 0 to about 50 times a diameter of the outlet opening beyond the outer metal sleeve.
- [14] The above and other aspects, features and advantages of the present disclosure will be apparent from the following detailed description of the illustrated embodiments thereof which are to be read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

- [15] A more complete understanding of the exemplary embodiments of the present disclosure and the advantages thereof may be acquired by referring to the following description in consideration of the accompanying drawings in which like reference numbers indicate like features and wherein:
- [16] FIG. 1 is a schematic flow diagram of an aspect in accordance with various aspects described herein as applied to the manufacture of acrylonitrile product.
- [17] FIG. 2 illustrates an aspect of an inlet nozzle.
- [18] FIG. 3 illustrates an alternative aspect of an inlet nozzle.
- [19] FIG. 4 illustrates another alternative aspect of an inlet nozzle.
- [20] FIG. 5 illustrates an aspect of an inlet conduit.
- [21] FIG. 5 illustrates a more detailed view of an inlet conduit shown in a FIG. 5.
- [22] FIG. 6 illustrates a flow diagram of a process in accordance with aspects of the disclosure.

DETAILED DESCRIPTION

- [23] Concentrated acid, such as sulfuric acid is not particularly corrosive and carbon steel may be acceptable to convey sulfuric acid. Aqueous quench water is moderately corrosive, and requires another type of steel, e.g., 304L stainless steel. It has been found that the mixing of concentrated sulfuric acid into an aqueous quench stream may result in a localized zone of sulfuric acid that is highly corrosive and wherein neither carbon steel nor stainless steel may be suitable. It has been found that when another type of metal, e.g., a superalloy like Hastelloy B, is used for an acid injection nozzle there may still be corrosion issues. In this aspect, a polymer and metal are combined to provide an injection inlet nozzle that has improved corrosion resistance.
- [24] In an aspect, an apparatus comprises an inlet nozzle. The nozzle comprises an elongated cylinder having a longitudinal axis. The elongated cylinder comprises a polymer extending between a first end and a second end of the elongated cylinder. In this aspect, the polymer may be a polymer selected from the group consisting of

polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.

- [25] The second end of the elongated cylinder defines an outlet opening, wherein the outlet opening is transverse to the longitudinal axis of the elongated cylinder. In this aspect, the outlet opening may form an angle of about 30° to about 150° from the longitudinal axis of the elongated cylinder, in another aspect, about 60° to about 120°, and in another aspect, about 80° to about 100° from the longitudinal axis of the elongated cylinder.
- [26] The elongated cylinder comprises a channel in fluid communication with the inlet opening and the outlet opening. In an aspect, the elongated cylinder is configured to receive an acid through the inlet opening and convey the acid through the channel to the outlet opening, and convey the acid through the outlet opening. The channel may be spherical but may also be any other shape that can be formed into the polymer block. In this aspect, the channel has a diameter of about 0.5 cm to about 6.5 cm, in another aspect, about 1 cm to about 5 cm, and in another aspect, about 1.5 cm to about 4 cm.
- [27] In an aspect, a first portion of the elongated cylinder is encased in a metal, and a second portion of the elongated cylinder is not encased by the metal. In an alternative aspect, the elongated cylinder is encased in metal up to its outlet opening. The metal may be a Mo-containing alloy and the Mo-containing alloy may have about 2 weight percent or more Mo. Examples of Mo-containing alloys that may be utilized include Hastelloy®, Inconel®, Ferralium®, Nitronic®, and Carpenter® (Hastelloy is a registered trade name Haynes International, Inc., Inconel is a registered trade name of INCO, Ferralium is a registered trade name of Langley Alloys, Ltd., Nitronic is a registered trade name of Amco, Inc., and Carpenter is a registered trade name of Langley Alloys, LTD.).
- [28] In an aspect, the inlet nozzle may be used in combination with a conduit that conveys a process stream in a predetermined direction that is transverse to the longitudinal axis of the elongated cylinder of the inlet nozzle. In an aspect, the outlet opening is configured to convey acid in the same direction as the predetermined direction of the process stream flowing through the conduit.

- [29] The apparatus and method of the present disclosure will now be described in further detail with reference to the figures.
- [30] FIG. 1 is a schematic flow diagram of an embodiment in accordance with aspects of the disclosure as applied to the manufacture of acrylonitrile product. Apparatus 100 may comprise quench column 10. Quench column 10 may be configured to receive reactor effluent 12 from an ammoxidation reactor (not shown in FIG. 1) via conduit 14. In quench column 10, the hot reactor effluent gases are cooled by contact with an aqueous stream or quench liquid 16 entering quench column 10 via lines 18, 20, 22, and 24. The cooled effluent gas comprising acrylonitrile (including co-products such as acetonitrile, hydrogen cyanide and impurities) may then be passed through an entrainment separator 26, and then to an absorber column (not shown).
- [31] As shown in FIG. 1, quench vessel 10 comprises a first portion 28 and a second portion 30, wherein first portion 28 is located below the second portion 30. First portion 28 of the quench vessel 10 comprises an inlet 32 configured to receive a gas stream or reactor effluent 12, wherein the gas stream or reactor effluent 12 comprises acrylonitrile and ammonia. Second portion 30 of the quench vessel 10 comprises a multi-level spray system 34 that is configured to receive an aqueous stream or quench liquid 16, wherein the aqueous stream or quench liquid 16 comprises an acid 36. Acid 36 may be added via line 38 to quench liquid 16 at juncture 40. Acid 36 may be any suitable acid, e.g., sulfuric acid (such as 95-98% by weight sulfuric acid). Quench liquid 16 comprises effluent exiting bottom 42 of quench vessel 10 and through line 44. Water may be added via line 46 to quench vessel 10 through inlet 48, or otherwise may be added to quench liquid 16 or elsewhere in the liquid recycle loop formed by streams 17, 44, and 65. Quench liquid 16 is circulated through line 44 and back to lines 18, 20, 22, and 24, using pump 50. A purge stream 67 may be withdrawn as part of the liquid effluent exiting through line 44, in order to maintain a relatively constant mass flow in the liquid recycle loop by offsetting the liquid added via lines 38 and 46. Purge stream 67 removes formed neutralization reaction products (e.g., ammonium sulfate) and is also useful for preventing the accumulation of unwanted products in the liquid recycle loop, such as corrosion products. Effluent exiting bottom 42 of quench vessel 10 may be drawn from line 44 at siphon point 52.

- [32] Multi-level spray system 34 comprises at least a first spray bar 54, corresponding to line 18, and a second spray bar 56 corresponding to line 20. As shown in FIG. 1, multi-level spray system 34 also comprises spray bar 58, corresponding to line 22, and spray bar 60, corresponding to line 24. Spray bars 54, 56, 58, and 60 extend substantially across a diameter 62 of quench vessel 10. As shown, spray bar 54 is located below spray bar 56, and substantially parallel to spray bar 56. Spray bar 58 is located above spray bar 56, and below spray bar 60. Spray bar 58 is substantially parallel to spray bar 60.
- [33] Spray bars 54, 56, 58, and 60 may each comprise a series of spray arms (not shown in FIG. 1). Spray arms may extend substantially across diameter or chords of quench vessel 10 that are perpendicular to diameter 62 of quench vessel 10. Each spray arm may comprise two or more extenders (not shown in FIG. 1). Each extender may extend substantially perpendicular to its respective spray arm. Each extender may comprise a spray nozzle at an end of its respective extender, wherein each spray nozzle faces downward. In an aspect, each nozzle of spray system 34 may be configured to downwardly spray a hollow cone spray of the quench liquid 16, wherein each hollow cone spray defines a center equidistant from the walls of the hollow cone spray. In an aspect, the nozzles of each spray bar may be spaced so that a portion of a first hollow cone spray of quench liquid from a first nozzle of the first spray bar overlaps with a portion of a second hollow cone spray of quench liquid from a second nozzle of the first spray bar to provide an overlap of the quench liquid, having an overlap center.
- [34] Cooled effluent gas comprising acrylonitrile (including co-products such as acetonitrile, hydrogen cyanide and impurities) along with mist may then rise up from multi-level spray system 34 to mist eliminator 26. Mist eliminator 26 is configured to remove mist from the cooled effluent gas. Mist eliminator 26 is located downstream of the second portion 30 of the quench vessel 10. Mist eliminator 26 may comprise a water spray system 100. Water spray system 100 is configured to spray water to a surface 102 of mist eliminator 26, wherein collection of droplets is reduced and corresponding formation of fouling and formation of polymer on surfaces 102 of mist eliminator 26 reduced. As shown in FIG. 1, water spray system 100 comprises a water line 104 that feeds water to spray bar 106 through inlet 108.

- [35] Spray bar 106 may comprise a series of spray arms (not shown in FIG. 1). The spray arms of spray 106 may extend substantially across diameter or chords of quench vessel 10 that are perpendicular to diameter 62 of quench vessel 10. Each spray arm of spray bar 106 may comprise two or more extenders (not shown in FIG. 1). Each extender may extend substantially perpendicular to its respective spray arm. Each extender may comprise a spray nozzle at an end of its respective extender, wherein each spray nozzle faces upward. In an aspect, each nozzle of water spray system 100 may be configured to upwardly spray a full cone spray of water, wherein each full cone spray defines a center equidistant from the walls of the full cone spray. In an aspect, the nozzles of spray bar 106 may be spaced so that a portion of a first full cone spray of water from a first nozzle of spray bar 106 overlaps with a portion of a second full cone spray of water from a second nozzle of spray bar 106 to provide an overlap of the water having an overlap center.
- [36] Upward spray of water 110 from the nozzles of spray bar 106 to surfaces 102 of mist eliminator 26 may be controlled and/or timed by an automated controller or timer 112. Controller 112 may control the opening and closing of valve 114 via communication line 116. As shown in FIG. 1, mist eliminator 26 may comprise a chevron arrangement or horizontal chevrons 118 having surfaces 102. Chevron arrangement or horizontal chevrons 118 extend along a cross-section of mist eliminator 26. Nozzles 120 of spray bar 106 are configured to provide an upward spray of water 110, preferably as full cone sprays, to surfaces 102, thereby preventing or reducing the formation of foulants and polymer on surfaces 102. While chevron arrangement 118 is shown in FIG. 1, as previously noted, demisting or coalescing material or structure may be selected from the group consisting of steel wool pads, vanes, and chevron style arrangements.
- [37] The quenched or cooled effluent gas comprising acrylonitrile (including co-products such as acetonitrile, hydrogen cyanide and impurities), after passing through mist eliminator 26, may exit quench vessel 10 as gas stream 13. Gas stream 13 may be passed through conduit 15 to an absorber column (not shown).
- [38] In an aspect, controller 11 may be configured to process one or more signals corresponding to a measured parameter, e.g., the temperature measured by a temperature controller (not shown in FIG. 1). Controller 11 may be configured to

determine whether the measured parameter is above or below a predetermined parameter range. Those skilled in the art will recognize that in accordance with the disclosure, the measured parameter may any suitable parameter useful in operation of the quench vessel, e.g., a temperature measured by the temperature controller at a predetermined location, or a liquid level measured by a level controller (not shown in FIG. 1) in boot 45 of the quench vessel 10, or a flow controller (not shown in FIG. 1). Controller 11 may be configured to adjust operation of one or more devices via communication lines or wireless communications (not shown in FIG. 1) if the measured parameter is below or above a predetermined parameter range. For example, controller 11 may be configured to adjust the amount of a stream conveyed to quench vessel 10, e.g., streams such as reactor effluent 12, water (conveyed through line 46 to quench vessel 10), and/or quench liquid 16 (including acid 36 conveyed through line 38). Those skilled in the art will recognize that in accordance with the disclosure, controller 11 may be configured to control operation of pump 50 and/or operation of other pumps and/or valves associated with the above streams in order to meet the predetermined range. Those skilled in the art will recognize that controller 11 may be configured to control operation of valve 114 or controller 112, which in turn may be configured to control operation of valve 114. Those skilled in the art will recognize that controller 11 may be configured to control operation other device(s) such as valve 222 (shown in FIG. 2 and further discussed below). Those skilled in the art will recognize that controller 11 may be configured to control operation other device(s) such as a pump (not shown) associated with the flow of water to spray bar 106 through inlet 108. Those skilled in the art will recognize that controller 11 or a similar controller may be located remote from a temperature controller, a level controller, or flow controller (not shown in FIG. 1), or may be located at and comprise a temperature controller, a level controller, or a flow controller.

- [39] The effluent from the ammoxidation reactor generally contains a certain amount of ammonia. Therefore, quench liquid 16 used in quench column 10 may also contain a strong mineral acid 36, such as sulfuric acid, to react with and thereby form a water soluble salt of ammonia, such as ammonium sulfate.

- [40] As previously noted, acid 36 may be added to quench liquid 16 at juncture 40. FIG. 2 illustrates an embodiment of an inlet nozzle 200 at juncture 40 for addition of acid 36 to quench liquid 16.
- [41] Nozzle 200 may comprise an elongated cylinder 202 having a longitudinal axis along line A—A. Elongated cylinder 202 may comprise synthetic fluoropolymer 204 extending between first end 206 and a second end 208 of the elongated cylinder 202. In an aspect, synthetic fluoropolymer 204 may comprise polytetrafluoroethylene (PTFE). PTFE may be sold under the brand name Teflon® by DuPont Co.
- [42] First end 206 may define inlet opening 210, wherein inlet opening 210 may be is transverse to the longitudinal axis A—A of elongated cylinder 202. Elongated cylinder 202 may comprise an outlet opening 212 located between first end 206 and second end 208, wherein outlet opening 212 may be parallel to the longitudinal axis A—A of elongated cylinder 202. Elongated cylinder 202 may comprise channel 214 in fluid communication with inlet opening 210 and the outlet opening 212. In an aspect, elongated cylinder 202 may be configured to receive acid 36 through inlet opening 210, convey acid 36 through channel 214 to outlet opening 212, and convey acid 36 through outlet opening 212. In one aspect, a first portion 216 of elongated cylinder 202 may be encased in alloy 218, and a second portion 220 that is not encased by the alloy 218. In an aspect, second portion 220 of elongated cylinder 202 comprises outlet 212 opening and second end 208.
- [43] In an aspect, alloy 218 may comprise a superalloy. For example, superalloy may comprise Hastelloy B or a similar superalloy.
- [44] In an aspect, outlet opening 212 and channel 214 may be formed by drilling from first end 206 into elongated cylinder 202 parallel to longitudinal axis A—A. Outlet opening 212 may be formed by drilling into elongated cylinder 202 in a direction that is transverse to longitudinal axis A—A. The above drilling may be performed using a suitable drill to drill through polymer 204 of elongated cylinder 202. The flow of acid 36 to inlet opening 210 may be controlled by controlling the opening and closing valve 222.
- [45] In an aspect, elongated cylinder 202 may be used in combination with conduit 224 that conveys a process stream in a predetermined direction that is transverse to the

longitudinal axis A—A of elongated cylinder 202. In an aspect, second portion 220 of elongated cylinder 202 may be placed in conduit 224 so that outlet opening 212 is configured to convey acid 36 through outlet opening 212 in the same direction as the predetermined direction of the water flowing through conduit 224.

- [46] In an aspect, nozzle 200 may be configured so that when nozzle 200 is combined with conduit 224, outlet opening 212 has a top 226 that aligns with the center line 228 of conduit 224. In an aspect, outlet opening 212 may be located along another portion of the elongated cylinder, for example in a location such that when nozzle 200 is combined with conduit 224, outlet opening 212 may have a center that aligns with the center line 228 of conduit 224. In an aspect, outlet opening 212 may have a different location along elongated cylinder 202 so that another point of outlet opening 212 aligns with center line 228 of conduit 224, e.g., the center of the outlet opening 212 aligns with center line 228 of conduit 224, or a point of outlet opening 212 between top 226 and the center of outlet opening 212. In one aspect, the inlet nozzle may extend into the conduit perpendicular to the process stream. In another aspect, the inlet nozzle may extend into the conduit at an angle. In this aspect, the inlet nozzle forms an angle of about 30° to about 150° from the longitudinal axis of the elongated cylinder, in another aspect, about 60° to about 120°, and in another aspect, about 80° to about 100°.
- [47] In an aspect, conduit 224 may comprise an alloy. In an aspect, the alloy may be a Mo-containing alloy, such as carbon steel, or a superalloy, such as Hastelloy B or a similar superalloy. In an aspect, conduit 224 may comprise a superalloy at section 230 of conduit 224, and comprise an alloy a predetermined distance away from juncture at sections 232 and 234 of conduit 224.
- [48] In an aspect, section 230 of conduit 224 may comprise a lining or inner sleeve 236 comprising a polymer, which may be the same material as or similar to polymer 204 of elongated cylinder 202.
- [49] In an aspect, nozzle 200 is configured to deliver acid 36 into conduit 224 at a location where acid 36 will mix with water flowing through conduit 224 and where no metal of nozzle 200 is present at outlet opening 212. Since no metal of nozzle 200 is present at outlet opening 212, there may be reduced localized zones of sulfuric acid

that is highly corrosive than in a delivery system wherein carbon steel, stainless steel, or a superalloy is present at the acid nozzle opening.

[50] FIG. 3 illustrates another aspect where the nozzle 200 is encased in metal 218. As shown in FIG. 3, metal 218 may fully encase nozzle 200 up to outlet opening 212. In this aspect, the metal is spaced about 0 to about 50 times a diameter of the outlet opening away from the outlet opening, in another aspect, about 0 to about 25 times, in another aspect, about 0 to about 10 times, in another aspect, about 0 to about 5 times, in another aspect, about 0 to about 1 times, in another aspect, about 0 to about 0.5 times, in another aspect, about 0 to about 0.25 times, in another aspect, about 0.25 to about 50 times, in another aspect, about 0.25 to about 25 times, in another aspect, about 0.25 to about 10 times, in another aspect, about 0.25 to about 5 times, in another aspect, about 0.25 to about 1 times, in another aspect, about 0.25 to about 0.5 times, in another aspect, about 0.5 to about 50 times, in another aspect, about 0.5 to about 25 times, in another aspect, about 0.5 to about 10 times, in another aspect, about 0.5 to about 5 times, in another aspect, about 0.5 to about 1 times, in another aspect, about 1 to about 50 times, in another aspect, about 1 to about 25 times, in another aspect, about 1 to about 10 times, in another aspect, about 1 to about 5 times, in another aspect, about 10 to about 50 times, in another aspect, about 10 to about 25 times, in another aspect, about 10 to about 20 times, in another aspect, about 10 to about 15 times, in another aspect, about 15 to about 50 times, in another aspect, about 15 to about 25 times, in another aspect, about 15 to about 20 times, in another aspect, about 20 to about 50 times, in another aspect, about 20 to about 40 times, and in another aspect, about 20 to about 30 times or more a diameter of the outlet opening away from the outlet opening.

[51] FIG. 4 illustrates an alternative embodiment that may have the same or similar features as the embodiment shown in FIG. 2 and described above. Thus, while some of the features shown in FIG. 2 are not shown in FIG. 4, those skilled in the art will recognize that in accordance with the disclosure, the same or similar features of FIG. 2 may be incorporated in the embodiment shown in FIG. 4. Nozzle 300 may have an inlet opening 310 and a outlet opening 312. Nozzle 300 may be held in place in relation to conduit 324 by flange 350. Conduit 324 may be the same as or similar to conduit 224 shown and described with respect to FIG. 2. Since no metal of nozzle

300 is present at outlet opening 312, there may be reduced localized zones of sulfuric acid that is highly corrosive than in a delivery system wherein carbon steel, stainless steel, or a superalloy is present at the acid nozzle opening.

- [52] FIG. 5 illustrates an alternative embodiment that may have the same or similar features as the embodiment shown in FIG. 2 and described above. Thus, while some of the features shown in FIG. 2 are not shown in FIG. 5, those skilled in the art will recognize that in accordance with the disclosure, the same or similar features of FIG. 2 may be incorporated in the embodiment shown in FIG. 5.
- [53] Inlet conduit 400 may include a dual inlet configuration having a first inlet conduit 460 and a second inlet conduit 462. Each inlet conduit may have an inlet opening 410, and an outlet opening 412. Outlet opening 412 may be similar to outlet opening 212 shown and described with respect to FIG. 2. However, outlet opening 412 is parallel to longitudinal axis A—A of elongated cylinder 402 of each inlet conduit. In an aspect, elongated cylinder 402 comprises a polymer at outlet opening 412, and no metal is present at outlet opening 412. In an aspect, center 426 of each outlet opening 412 is equidistant to center line 428 of conduit 424. In an aspect, water may flow into conduit 424 from conduit 464, and flow out of conduit 424 through conduit 466.
- [54] FIG. 6 is a more detailed view of inlet conduit 460 shown in FIG. 5. Inlet conduit 462 may have the same configuration as inlet conduit 460. As shown in FIG. 6, elongated cylinder 402 has a length that is longer than the length of alloy encasement 418. Thus, first portion 416 of elongated cylinder 402 may be encased in alloy encasement 418, and second section 420 of elongated cylinder 402 may not be encased in alloy encasement 418.
- [55] Since no metal of inlet conduit 460 of nozzle 400 is present at opening 412, there may be reduced localized zones of sulfuric acid that is highly corrosive than in a delivery system wherein carbon steel, stainless steel, or a superalloy is present at the acid nozzle opening. In an aspect, the second end of the polymer sleeve extends about 0 to about 50 times or more a diameter of the outlet opening beyond the outer metal sleeve. In another aspect, the outlet opening is within about 60° to parallel to a longitudinal axis of the conduit, in another aspect, about 30° to parallel, and in another aspect, about 15° to parallel to a longitudinal axis of the conduit.

- [56] FIG. 7 illustrates a flow diagram of process 600 in accordance with aspects of the disclosure. Process 600 may be carried out or practiced by using the apparatus previously described with respect to FIG. 1, FIG. 2, FIG. 3, FIG. 4, and/or FIG. 5. In an aspect, step 601 may comprise placing an inlet nozzle opening into a conduit. In an aspect, step 602 may comprise conveying water through the conduit in a predetermined direction. In an aspect, step 603 may comprise conveying an acid through the inlet nozzle, wherein the conveying comprises conveying the acid through an outlet opening of the inlet nozzle in the same predetermined direction as the water, wherein the outlet opening comprises a fluoropolymer and is devoid of an alloy.
- [57] Process 600 may further comprise additional steps as previously described (but not shown in FIG. 6).
- [58] While in the foregoing specification this disclosure has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purpose of illustration, it will be apparent to those skilled in the art that the disclosure is susceptible to additional embodiments and that certain of the details described herein can be varied considerably without departing from the basic principles of the disclosure. It should be understood that the features of the disclosure are susceptible to modification, alteration, changes or substitution without departing from the spirit and scope of the disclosure or from the scope of the claims. For example, the dimensions, number, size and shape of the various components may be altered to fit specific applications. Accordingly, the specific embodiments illustrated and described herein are for illustrative purposes only.

WE CLAIM:

1. An inlet nozzle comprising:
an elongated polymer cylinder having a first end defining an inlet opening and a second end defining an outlet opening;
a channel within the elongated polymer cylinder, the channel effective for providing fluid communication between the inlet opening and the outlet opening; and
a metal encasing at least a portion of the elongated polymer cylinder.
2. The inlet nozzle of claim 1 wherein the metal is spaced about 0 to about 50 times a diameter of the outlet opening away from the outlet opening.
3. The inlet nozzle of claim 1 wherein the metal is spaced about 0.25 to about 50 times a diameter of the outlet opening away from the outlet opening.
4. The inlet nozzle of claim 1 wherein the metal is spaced about 0.25 to about 25 times a diameter of the outlet opening away from the outlet opening.
5. The inlet nozzle of claim 1 wherein the metal is spaced about 0.25 to about 1 times a diameter of the outlet opening away from the outlet opening.
6. The inlet nozzle of claim 1 wherein the outlet opening is transverse to a longitudinal axis of the elongated cylinder.
7. The inlet nozzle of claim 6 wherein the outlet opening forms an angle of about 30° to about 150° from the longitudinal axis of the elongated cylinder.
8. The inlet nozzle of claim 1 wherein the polymer is selected from the group consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.
9. The inlet nozzle of claim 8 wherein the polymer includes polytetrafluoroethylene.

10. The inlet nozzle of claim 1 wherein the metal is a Mo-containing alloy.
11. The inlet nozzle of claim 10 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.
12. An inlet conduit comprising:
an inner polymer sleeve and an outer metal sleeve,
the inner polymer sleeve having a first end defining an inlet opening and a second end defining an outlet opening,
the outer sleeve defining a first end and a second end.
13. The inlet conduit of claim 12 wherein the second end of the polymer sleeve extending about 0 to about 50 times or more a diameter of the outlet opening beyond the outer metal sleeve.
14. The inlet nozzle of claim 12 wherein the metal is spaced about 0.25 to about 50 times a diameter of the outlet opening away from the outlet opening.
15. The inlet nozzle of claim 12 wherein the metal is spaced about 0.25 to about 25 times a diameter of the outlet opening away from the outlet opening.
16. The inlet nozzle of claim 12 wherein the metal is spaced about 0.25 to about 1 times a diameter of the outlet opening away from the outlet opening.
17. The inlet conduit of claim 12 wherein the outlet opening is within about 60° to parallel to a longitudinal axis of the conduit.
18. The inlet conduit of claim 12 wherein the polymer is selected from the group consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.
19. The inlet conduit of claim 18 wherein the polymer includes polytetrafluoroethylene.

20. The inlet conduit of claim 12 wherein the metal is a Mo-containing alloy.
21. The inlet conduit of claim 20 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.
22. A process for providing acid to a process stream, the process comprising:
supplying acid through an inlet nozzle to a process stream,
wherein the inlet nozzle includes an elongated polymer cylinder having a first end defining an inlet opening and a second end defining an outlet opening;
a channel within the elongated polymer cylinder, the channel effective for providing fluid communication between the inlet opening and the outlet opening; and
a metal encasing at least a portion of the elongated polymer cylinder.
23. The process of claim 22 wherein the metal is spaced about 0 to about 50 times a diameter of the outlet opening away from the outlet opening.
24. The process of claim 22 wherein the metal is spaced about 0.25 to about 50 times a diameter of the outlet opening away from the outlet opening.
25. The process of claim 22 wherein the metal is spaced about 0.25 to about 25 times a diameter of the outlet opening away from the outlet opening.
26. The process of claim 22 wherein the metal is spaced about 0.25 to about 1 times a diameter of the outlet opening away from the outlet opening.
27. The process of claim 22 wherein the outlet opening is transverse to a longitudinal axis of the elongated cylinder.
28. The process of claim 27 wherein the outlet opening forms an angle of about 30° to about 150° from the longitudinal axis of the elongated cylinder.
29. The process of claim 22 wherein the polymer is selected from the group consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.

30. The process of claim 29 wherein the polymer includes polytetrafluoroethylene.
31. The process of claim 22 wherein the metal is a Mo-containing alloy.
32. The process of claim 31 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.
33. The process of claim 22 wherein the acid is a mineral acid selected from the group consisting of sulfuric acid, hydrochloric acid, phosphoric acid, boric acid, hydrofluoric acid, hydrobromic acid, perchloric acid, and mixtures thereof.
34. The process of claim 33 wherein the acid is about 95 to about 98 weight percent sulfuric acid.
35. The process of claim 22 wherein the process stream is a process stream in an oxidation or ammoxidation process.
36. A process for providing acid to a process stream, the process comprising:
supplying acid through an inlet conduit to a process stream,
wherein the inlet conduit includes
the inner polymer sleeve having a first end defining an inlet opening and a second end defining an outlet opening,
the outer sleeve defining a first end and a second end.
37. The process of claim 36 wherein the second end of the polymer sleeve extends about 0 to about 50 times a diameter of the outlet opening beyond the outer metal sleeve.
38. The process of claim 36 wherein the metal is spaced about 0.25 to about 50 times a diameter of the outlet opening away from the outlet opening.
39. The process of claim 36 wherein the metal is spaced about 0.25 to about 25 times a diameter of the outlet opening away from the outlet opening.

40. The process of claim 36 wherein the metal is spaced about 0.25 to about 1 times a diameter of the outlet opening away from the outlet opening.

41. The process of claim 36 wherein the outlet opening is within about 60° to parallel to a longitudinal axis of the conduit.

42. The process of claim 36 wherein the polymer is selected from the group consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.

43. The process of claim 42 wherein the polymer includes polytetrafluoroethylene.

44. The process of claim 36 wherein the metal is a Mo-containing alloy.

45. The process of claim 44 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.

46. The process of claim 36 wherein the acid is a mineral acid selected from the group consisting of sulfuric acid, hydrochloric acid, phosphoric acid, boric acid, hydrofluoric acid, hydrobromic acid, perchloric acid, and mixtures thereof.

47. The process of claim 46 wherein the acid is about 95 to about 98 weight percent sulfuric acid.

48. The process of claim 36 wherein the process stream is a process stream in an oxidation or ammoxidation process.

49. An acid addition system comprising:
a process stream conduit and an inlet nozzle extending into the process stream conduit;
the inlet nozzle including an elongated polymer cylinder having a first end defining an inlet opening and a second end defining an outlet opening;

a channel within the elongated polymer cylinder, the channel effective for providing fluid communication between the inlet opening and the outlet opening; and
a metal encasing at least a portion of the elongated polymer cylinder.

50. The acid addition system of claim 49 wherein the metal is spaced about 0 to about 50 times a diameter of the outlet opening.

51. The acid addition system of claim 49 wherein the metal is spaced about 0.25 to about 50 times a diameter of the outlet opening away from the outlet opening.

52. The acid addition system of claim 49 wherein the metal is spaced about 0.25 to about 25 times a diameter of the outlet opening away from the outlet opening.

53. The acid addition system of claim 49 wherein the metal is spaced about 0.25 to about 1 times a diameter of the outlet opening away from the outlet opening.

54. The acid addition system of claim 49 wherein the inlet nozzle extends into the process stream at an angle of about 30° to about 150° from an axis of a flow of the process stream.

55. The acid addition system of claim 49 wherein the outlet opening is transverse to a longitudinal axis of the elongated cylinder.

56. The acid addition system of claim 55 wherein the outlet opening forms an angle of about 30° to about 150° from the longitudinal axis of the elongated cylinder.

57. The acid addition system of claim 49 wherein the polymer is selected from the group consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.

58. The acid addition system of claim 57 wherein the polymer includes polytetrafluoroethylene.

59. The acid addition system of claim 49 wherein the metal is a Mo-containing alloy.
60. The acid addition system of claim 59 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.
61. The acid addition system of claim 49 wherein the acid is a mineral acid selected from the group consisting of sulfuric acid, hydrochloric acid, phosphoric acid, boric acid, hydrofluoric acid, hydrobromic acid, perchloric acid, and mixtures thereof.
62. The acid addition system of claim 61 wherein the acid is about 95 to about 98 weight percent sulfuric acid.
63. The acid addition system of claim 49 wherein the process stream is a process stream in an oxidation or ammoxidation process.
64. An acid addition system comprising:
a process stream conduit and an acid inlet conduit extending into the process stream conduit;
the inlet conduit including an inner polymer sleeve and an outer metal sleeve,
the inner polymer sleeve having a first end defining an inlet opening and a second end defining an outlet opening,
the outer sleeve defining a first end and a second end.
65. The acid addition system of claim 64 wherein the second end of the polymer sleeve extends about 0 to about 30 times a diameter of the outlet opening beyond the outer metal sleeve.
66. The acid addition system of claim 64 wherein the metal is spaced about 0.25 to about 50 times a diameter of the outlet opening away from the outlet opening.
67. The acid addition system of claim 64 wherein the metal is spaced about 0.25 to about 25 times a diameter of the outlet opening away from the outlet opening.

68. The acid addition system of claim 64 wherein the metal is spaced about 0.25 to about 1 times a diameter of the outlet opening away from the outlet opening.

69. The acid addition system of claim 64 wherein the outlet opening is within about 60° to parallel to a longitudinal axis of the process stream conduit.

70. The acid addition system of claim 64 wherein the polymer is selected from the group consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.

71. The acid addition system of claim 70 wherein the polymer includes polytetrafluoroethylene.

72. The acid addition system of claim 64 wherein the metal is a Mo-containing alloy.

73. The acid addition system of claim 72 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.

74. The acid addition system of claim 64 wherein the acid is a mineral acid selected from the group consisting of sulfuric acid, hydrochloric acid, phosphoric acid, boric acid, hydrofluoric acid, hydrobromic acid, perchloric acid, and mixtures thereof.

75. The acid addition system of claim 74 wherein the acid is about 95 to about 98 weight percent sulfuric acid.

76. The acid addition system of claim 64 wherein the process stream is a process stream in an oxidation or ammoxidation process.

77. An apparatus comprising:
a reactor vessel configured to receive an aqueous stream; and
an acid inlet nozzle configured to provide acid to the aqueous stream,
wherein the acid inlet nozzle includes an elongated polymer cylinder having a first end defining an inlet opening and a second end defining an outlet opening;

a channel within the elongated polymer cylinder, the channel effective for providing fluid communication between the inlet opening and the outlet opening; and
a metal encasing at least a portion of the elongated polymer cylinder.

78. The apparatus of claim 77 wherein the metal is spaced about 0 to about 30 times a diameter of the outlet opening away from the outlet opening.

79. The apparatus of claim 77 wherein the metal is spaced about 0.25 to about 50 times a diameter of the outlet opening away from the outlet opening.

80. The apparatus of claim 77 wherein the metal is spaced about 0.25 to about 25 times a diameter of the outlet opening away from the outlet opening.

81. The apparatus of claim 77 wherein the metal is spaced about 0.25 to about 1 times a diameter of the outlet opening away from the outlet opening.

82. The apparatus of claim 77 wherein the outlet opening is transverse to a longitudinal axis of the elongated cylinder.

83. The apparatus of claim 82 wherein the outlet opening forms an angle of about 30° to about 150° from the longitudinal axis of the elongated cylinder.

84. The apparatus of claim 77 wherein the polymer is selected from the group consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride, polyvinylidene difluoride, and mixtures thereof.

85. The apparatus of claim 84 wherein the polymer includes polytetrafluoroethylene.

86. The apparatus of claim 77 wherein the metal is a Mo-containing alloy.

87. The apparatus of claim 86 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.

88. An apparatus comprising:
a reactor vessel configured to receive an aqueous stream; and
an inlet conduit configured to provide acid the aqueous stream,
wherein the inlet conduit includes an inner polymer sleeve and an outer metal sleeve,
the inner polymer sleeve having a first end defining an inlet opening and a second end
defining an outlet opening,
the outer sleeve defining a first end an a second end.

89. The apparatus of claim 88 wherein the second end of the polymer sleeve
extends about 0 to about 50 times a diameter of the outlet opening beyond the outer metal
sleeve.

90. The apparatus of claim 88 wherein the metal is spaced about 0.25 to about 50
times a diameter of the outlet opening away from the outlet opening.

91. The apparatus of claim 88 wherein the metal is spaced about 0.25 to about 25
times a diameter of the outlet opening away from the outlet opening.

92. The apparatus of claim 88 wherein the metal is spaced about 0.25 to about 1
times a diameter of the outlet opening away from the outlet opening.

93. The apparatus of claim 88 wherein the outlet opening is within about 60° to
parallel to a longitudinal axis of the conduit.

94. The apparatus of claim 88 wherein the polymer is selected from the group
consisting of polytetrafluoroethylene, perfluoro-elastomers, polyvinyl chloride,
polyvinylidene difluoride, and mixtures thereof.

95. The apparatus of claim 95 wherein the polymer includes
polytetrafluoroethylene.

96. The apparatus of claim 88 wherein the metal is a Mo-containing alloy.

97. The apparatus of claim 96 wherein the Mo-containing alloy includes about 2 weight percent or more Mo.

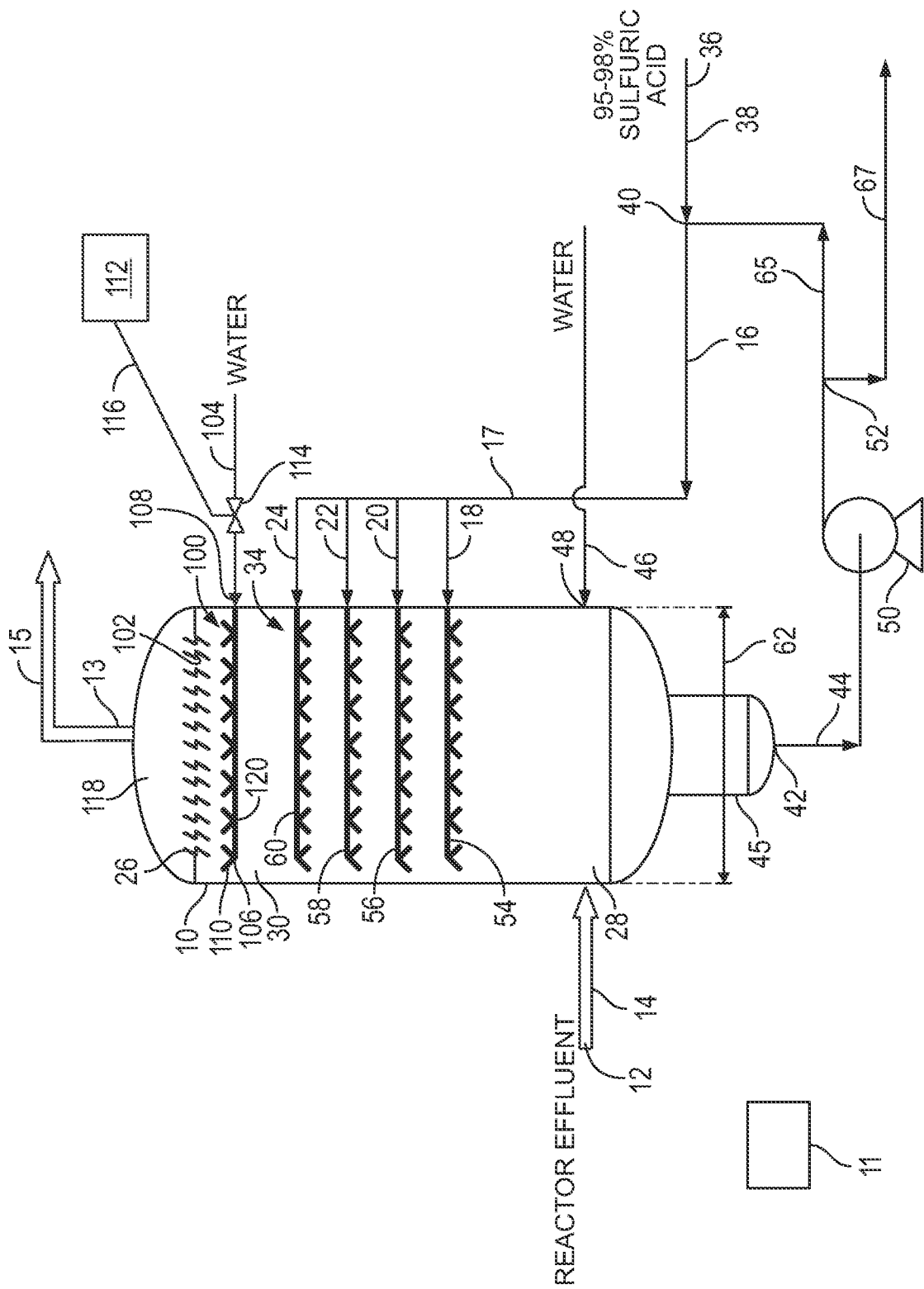


FIG. 1

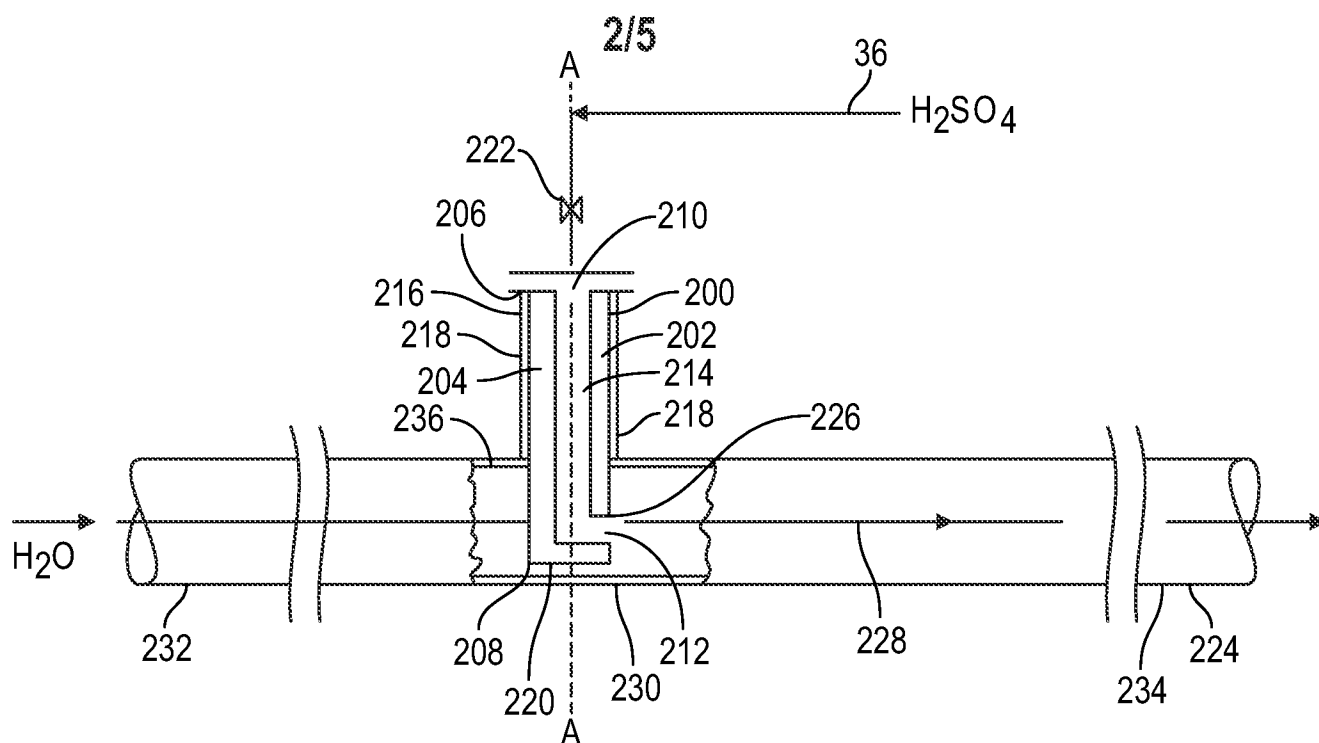


FIG. 2

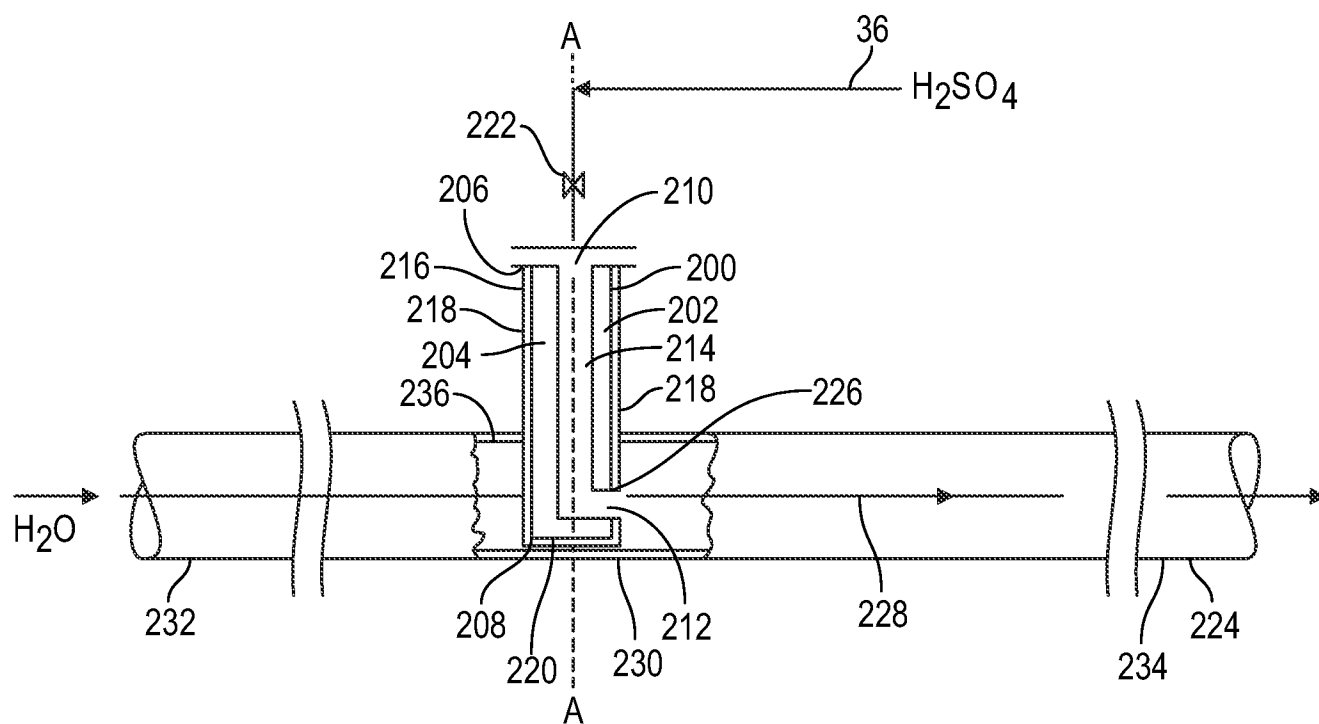


FIG. 3

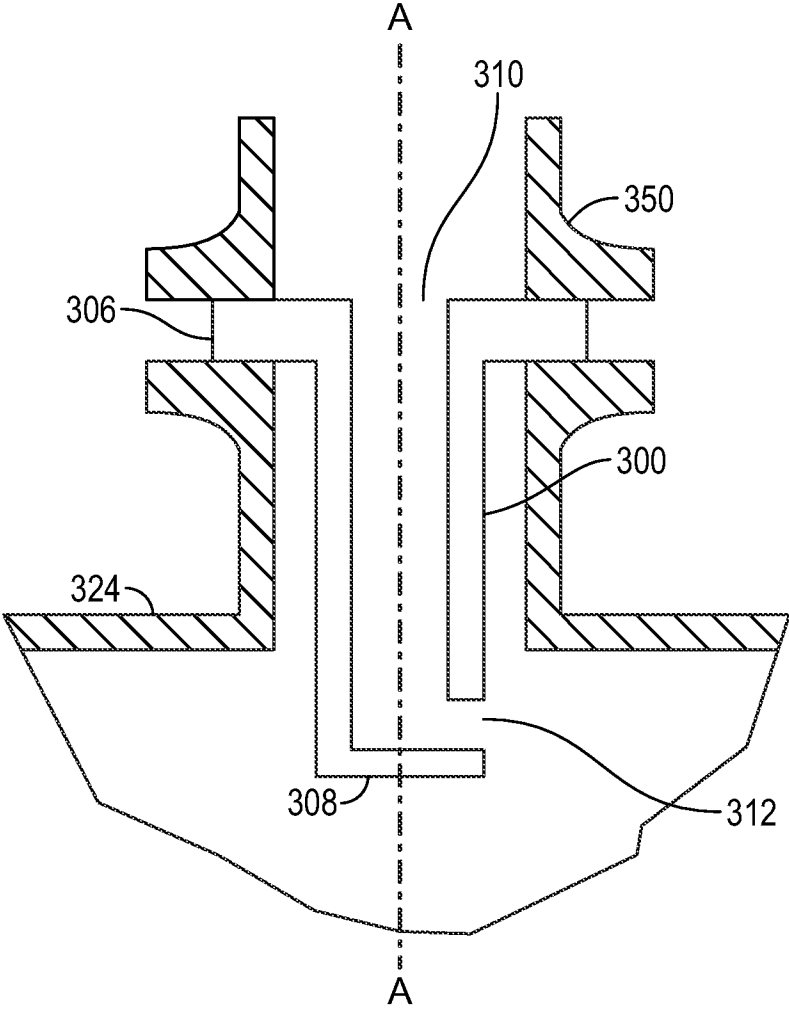


FIG. 4

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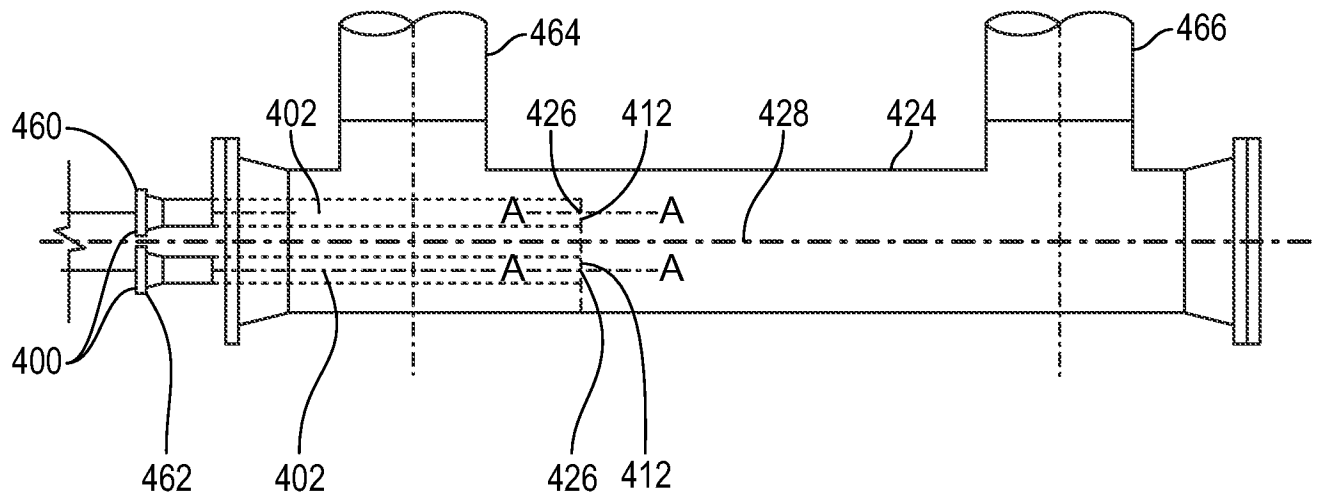


FIG. 5

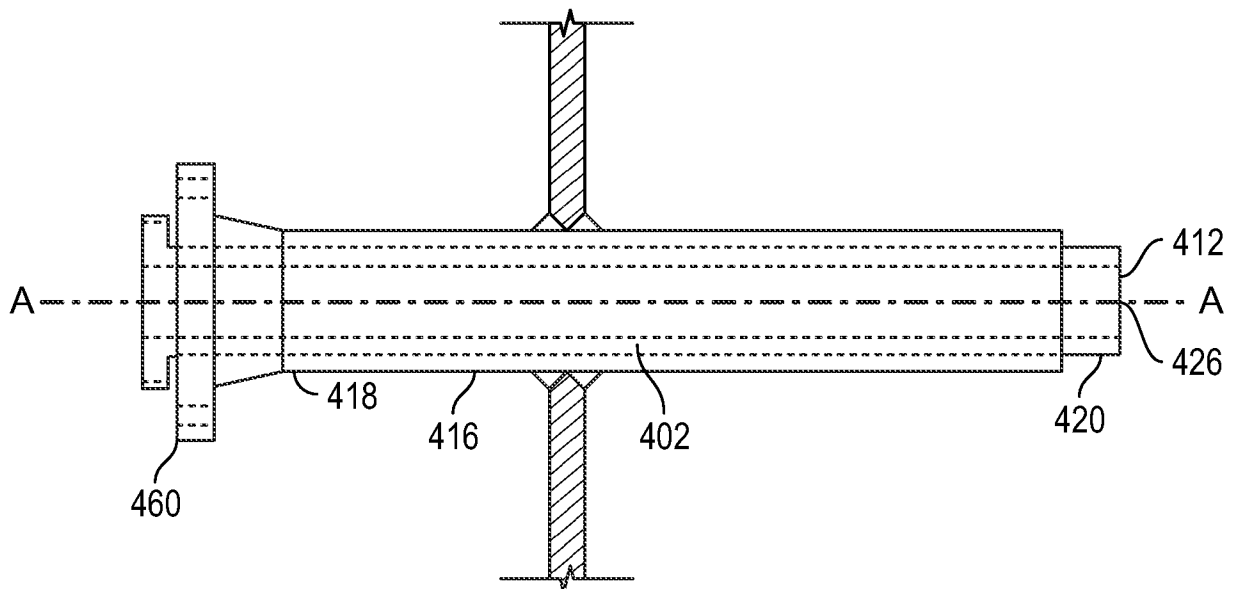


FIG. 6

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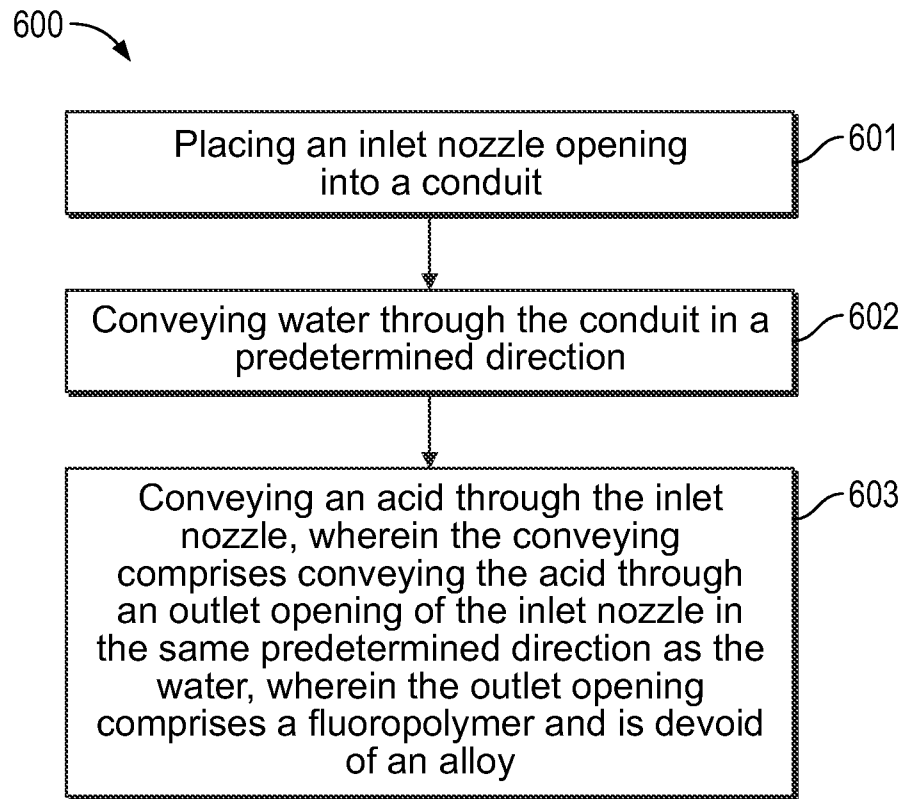


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/031685

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07C253/24 B01J4/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07C B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 594 903 A (JOHNSON KIRK B [US]) 17 June 1986 (1986-06-17) column 1, lines 9-10; claim 1; figure 1 ----- -/--	1-4,8,9, 12-15, 18,19, 22-25, 29,30, 33,34, 36-39, 42,43, 46, 77-80, 84,85, 88-91, 94,95

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

5 August 2015

Date of mailing of the international search report

14/08/2015

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Veronesi, Sergio

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/031685

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 3 282196 B2 (ONARI HIROBUMI) 13 May 2002 (2002-05-13) figure 4 -----	1,12,17, 22,36, 41,49, 64,69, 77,88,93

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/031685

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