PRESSURE VALVE ASSEMBLY

CROSS-REFERENCE

[0001] This application claims the benefits of U.S. Provisional Application No. 63/087,077, filed on October 2, 2020, U.S. Provisional Application No. 63/146,608, filed on February 6, 2021, and U.S. Provisional Application No. 63/153,740, filed on February 25, 2021, each of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] Valves are used to control the flow of materials in many industrial processes. The inside of a relief valve contains a plug that blocks or reduces the output of a source of material when the valve is pressurized. When the pressure behind the plug is released the plug is pushed back by the force of the pressure from this output. This allows the valve to be opened until the pressure behind the plug is equal or greater than the force of the output. If a valve is coupled to an actuator operating in response to the output, precise continuous movement is possible rather than with just a manual-operated or spring-operated valve.

[0003] When moving materials under pressure it can be difficult to control the pressure in the container through which they are transported. This is difficult for continuous or semi-continuous flow of a slurry of materials moving in one direction in critical operating states resulting from treatment of the media. In order to maintain a constant pressure and velocity of the moving material, a valve must be designed to operate to hold the pressure in the pipe or barrel at a constant while allowing for a certain velocity. This is especially true of particulate substances such as biomass moving in a liquid under high pressure where the valve is involved in further treatment and the flow of materials is rapid and surging. Such severe operating conditions can induce premature failure and leakage of the valve assembly, resulting in blowouts and extreme wear. Further, slurry particles can become trapped in the valve sealing cycle, resulting in performance degradation of the valve assembly. In general, pressure relief valves are not designed to handle such operations.

SUMMARY

[0004] In one aspect, the present disclosure refers to ~~provided herein is~~ a valve assembly comprising a valve body having an input end, a discharge end, and a chamber formed therein in connection with the input end and the discharge end, the input end attachable to a

tube with a fluid or slurry input that flows through the valve assembly; a conical valve needle that has a cone with a

wide end opposing to its conical tip and is axially displaceable in the chamber within the valve body; and a housing attached to the discharge end of the valve body and enclosing the valve needle when the valve needle is disengaged with the valve body; wherein the valve needle has a diameter at the wide end that is at least 4% larger than an inner diameter of the valve body at its discharge end.

[0005] In some ~~embodiment~~examples, the valve body has an annular ring that sits in a recessed cavity on an internal surface of the valve body at the discharge end. In some ~~embodiment~~examples, the annular ring is replaceable. In some ~~embodiment~~examples, an internal surface of the annular ring aligns with the internal surface of the valve body. In some ~~embodiment~~examples, the valve needle sits at the annular ring when closed in the valve body. In some ~~embodiment~~examples, the housing comprises therein a detachable discharge ring that sits adjacent to the discharge end of the valve body. In some ~~embodiment~~examples, the discharge ring has a tapered shape. In some ~~embodiment~~examples, the valve body comprises nozzles for input of a liquid. In some ~~embodiment~~examples, the chamber of the valve body forms a part of a reaction zone with the tube for a biomass pretreatment process. In some ~~embodiment~~examples, the tube is an extruder. In some ~~embodiment~~examples, the extruder is a twin screw extruder. In some ~~embodiment~~examples, the valve needle is operably linked to an actuator via a shaft. In some ~~embodiment~~examples, the actuator maintains a pressure on the valve needle. In some ~~embodiment~~examples, the actuator maintains a pressure of over 1,800 lbf on the valve needle. In some ~~embodiment~~examples, the actuator maintains a pressure of between 50,000 to 500,000 lbf on the valve needle. In some ~~embodiment~~examples, the valve body has a circular section at the discharge end, a circular collar at the input end that is smaller in inner diameter than the circular section at the discharge end, and an intercalary conical section therebetween. In some ~~embodiment~~examples, there is an annular space formed in the chamber between the valve needle and the valve body when the valve needle is closed on the valve body. In some ~~embodiment~~examples, the housing comprises a discharge pipe. In some ~~embodiment~~examples, an inner diameter of the housing at an end of the housing abutting the valve body is at least 7% larger than an inner diameter of the valve body at its discharge end. In some ~~embodiment~~examples, an inner diameter of the housing at an end of the housing abutting the valve body is about 7% larger than an inner diameter of the valve body at its discharge end. In some ~~embodiment~~examples, the cone of the conical valve needle is tapered in a range of from about 45 degrees to about 75 degrees. In some ~~embodiment~~examples, the cone of the conical valve needle is tapered about 45 degrees.

[0006] In another ~~aspect~~example, provided herein is a valve assembly comprising: a valve body comprising a large circular section, an intercalary conical section, and a small circular collar

containing one or more nozzles for liquid input, the valve body having a chamber formed therein that connects an input end and a discharge end of the valve body, wherein the small circular collar is smaller in inner diameter than the large circular section; a valve needle axially displaceable within the chamber of the valve body; and a housing attached to the discharge end of the valve body and enclosing the valve needle when the valve needle is disengaged with the valve body.

[0007] In another ~~aspect~~example, provided herein is a system for treating biomass through an extruder comprising: an extruder comprising one or more screws wherein an internal plug of biomass is formed due to action of the screws, thereby forming one end of a pressurized reaction zone; a means for supplying steam and chemicals to the reaction zone; and a valve assembly at an output end of the extruder that forms a downstream end of the reaction zone and adds a liquid to the reaction zone; wherein the valve assembly is capable of rapidly discharging pressurized treated biomass into a non-pressurized discharge area.

[0008] In one ~~aspect~~example, a valve assembly comprising a housing, a valve body, and a valve needle attached to a tube with an output that flows through the valve assembly is provided, wherein the valve comprises: a conical valve needle which is axially displaceable in an annular space of the valve body and on one end has a conical valve needle tip; and wherein the downstream inner diameter of the valve body is at least 4% larger than the inner wall of the housing. In one ~~embodiment~~example, the valve assembly has an annular ring that is part of the valve body and is replaceable.

[0008a] In another aspect, the present disclosure refers to a conical valve needle for engagement with a valve body that comprises a valve needle that extends beyond the valve body into a discharge area when the valve is closed.

[0009] In another ~~embodiment~~example, the valve assembly housing contains a detachable discharge ring. In another ~~aspect~~example, the valve body contains nozzles for the input of a liquid. In a further ~~embodiment~~example, the valve needle seats when closed in the valve body at the discharge ring. In one ~~aspect~~example, the valve assembly forms a part of a reaction zone with the tube. In a further ~~aspect~~example, the valve needle is attached to an actuator. In one ~~embodiment~~example, the actuator maintains a pressure on the valve needle, said pressure which is maintained over 1,800 lbf on the valve needle. In another ~~embodiment~~example, the actuator maintains a pressure of between 50,000 to 500,000 lbf on the valve needle.

[0009a] In yet another aspect, the present disclosure refers to a valve assembly comprising a valve body comprising a large circular section, an intercalary conical section, and a small circular collar containing one or more nozzles for liquid input, the valve body

having a chamber formed therein that connects an input end and a discharge end of the valve body, wherein the small circular collar is smaller in inner diameter than the large circular section, a valve needle axially displaceable within the chamber of the valve body, and a housing attached to the discharge end of the valve body and enclosing the valve needle when the valve needle is disengaged with the valve body.

[00010] In one ~~aspect~~example, the tube attached to the valve assembly is an extruder. In a further ~~aspect~~example, the extruder is a twin screw extruder.

[00011] In another ~~embodiment~~example, a conical valve needle for engagement with a valve body that comprises a valve needle that extends beyond the valve body into a discharge area when the valve is closed is provided. In one ~~aspect~~example, an annular ring is part of the valve body. In another ~~aspect~~example, the valve needle seats downstream of the annular ring. In a further

~~aspect~~example, the annular ring is replaceable. In one ~~embodiment~~example, a housing is attached downstream to the valve body containing a valve needle and the housing contains a detachable discharge ring. In another ~~embodiment~~example, the valve body contains nozzles for the input of a liquid. In another ~~embodiment~~example, the valve needle seats when closed in the valve body at the discharge ring. In a further ~~aspect~~example, the valve body and valve needle form a part of the reaction zone with the tube. In another ~~aspect~~example, the valve needle is attached to an actuator. In a further ~~aspect~~example, the actuator maintains a pressure on the valve needle. In a further ~~aspect~~example, the actuator maintains a pressure of over 1,800 lbf on the valve needle. In one ~~embodiment~~example, the actuator maintains a pressure between 50,000 to 500,000 lbf on the valve needle.

[00012] In one ~~embodiment~~example, the valve needle is in a valve body attached to an extruder. In a further ~~embodiment~~example, the extruder is a twin screw extruder.

[00013] In one ~~embodiment~~example is provided a valve assembly that becomes part of a reaction zone when attached to a tube or pipe. In another ~~embodiment~~example, the pipe or tube is an extruder. In a further ~~embodiment~~example, the extruder is a twin screw extruder. In another ~~embodiment~~example, at least part of the contents of the extruder are under pressure.

[00014] In one ~~embodiment~~example, a valve assembly is provided, wherein the pressurized zone of a tube or pipe or extruder extends into the valve assembly. In another ~~embodiment~~example, a valve assembly that has an increase in internal diameter between the end of the valve body where material is discharged and the diameter of the discharge housing.

[00015] In one ~~aspect~~example a valve assembly is provided for use in the pressurized passage of a fluid, slurry or other materials comprising a housing and a valve body comprising: a large circular section; a middle conical section; and a smaller circular collar section containing one or more nozzles for liquid input; and a valve needle. In another ~~aspect~~example the housing contains a removable discharge ring. In a further ~~aspect~~example, the discharge ring is tapered. In another ~~aspect~~example, the valve body contains an annular ring. In another ~~aspect~~example, the annular ring is removable. In another ~~embodiment~~example, there is a space between the valve body and the valve needle when the valve needle is seated. In a further ~~embodiment~~example, the nozzles for liquid input transfer water into the space between the valve body and the valve needle. In a further ~~embodiment~~example, the nozzles for liquid input transfer a liquid other than water into the space between the valve body and the valve needle. In a further ~~embodiment~~example, the liquid is selected from the group consisting of: an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof.

[00016] In another ~~embodiment~~example, a system for treating biomass through an extruder is provided comprising: an extruder comprising one or more screws wherein an internal plug of biomass is formed due to action of the screws, thereby forming one end of a pressurized reaction zone; a method of supplying steam and chemicals to the reaction zone; a valve assembly at the output end of the extruder that forms the downstream end of the reaction zone and adds a liquid to the reaction zone and is capable of rapidly discharging pressurized treated biomass into a non-pressurized discharge area. In another ~~aspect~~example, the biomass is selected from the group consisting of: silage, agricultural residues, com stover, bagasse, sorghum, nuts, nut shells, coconut shells, Distillers Dried Solubles, Distillers Dried Grains, Condensed Distillers Solubles Distillers Wet Grains, Distillers Dried Grains with Solubles, woody materials, sawdust, wood chips, timber slash, mill scrap, municipal waste, waste paper, recycled toilet papers, yard clippings, and energy crops such as poplars, willows, switchgrass, alfalfa, and prairie bluestem, non-woody plant matter, cellulosic material, lignocellulosic material, hemicellulosic material, carbohydrates, corn, sugar cane, grasses, switchgrass, high biomass sorghum, bamboo, corncobs, and peels and pits. In a further ~~aspect~~example, the biomass is treated for less than 60, 55, 50, 45, 40, 35, 30, 25, 20, 19, 18, 17, 16, 15, 14, 13, 12, 10, 9, 8, 7, 6, 5, 4, 3, 2, or 1 seconds in the reaction zone. In one ~~embodiment~~example, the temperature in the reaction zone is elevated to 50-500 °C, 75-400 °C, 100-350°C, 150-300°C, 200-250°C, 150-300°C, 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI. In another ~~embodiment~~example, the chemical is an acid. In a further ~~embodiment~~example, the acid is sulfuric acid.

[00016a] In yet another aspect, the present disclosure refers to a system for treating biomass through an extruder comprising an extruder comprising one or more screws wherein an internal plug of biomass is formed due to action of the screws, thereby forming one end of a pressurized reaction zone, a means for supplying steam and chemicals to the reaction zone, and a valve assembly at an output end of the extruder that forms a downstream end of the reaction zone and adds a liquid to the reaction zone, wherein the valve assembly is capable of rapidly discharging pressurized treated biomass into a non-pressurized discharge area.

[00017] In one ~~aspect~~example there is provided a system, wherein a valve assembly comprises a housing, and a valve body comprising: a large circular section; a middle conical section; a smaller circular collar containing one or more nozzles for liquid input; and a valve needle. In another ~~aspect~~example, the system has a valve assembly wherein the housing contains a removable discharge ring. In a further ~~aspect~~example, the discharge ring of the valve assembly is tapered. In another ~~embodiment~~example, the valve body of the valve assembly

contains an annular ring. In a further ~~embodiment~~example, the annular ring is removable. In another ~~aspect~~example, the valve body contains a space between the valve body and the valve needle when the valve needle is seated. In another ~~embodiment~~example, the valve assembly comprises nozzles for liquid input and transfer water into the space between the valve body and the valve needle. In a further ~~embodiment~~example, the nozzles for liquid input transfer a liquid other than water into the space between the valve body and the valve needle. In a further ~~embodiment~~example, the liquid comprises an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof.

[00018] In one ~~embodiment~~example, there is provided a method for treating a slurry or liquid in a pipe or barrel comprising: a pipe or barrel with a plug forming one end of a reaction zone, moving a liquid or slurry through the pipe or barrel, using a valve assembly attached to the output end of the pipe or barrel to form the downstream end of the reaction zone while maintaining pressure in the reaction zone, adding a liquid into the upstream end of the valve assembly as the liquid or slurry enters the valve assembly, and using the valve assembly to discharge treated liquid or slurry into a non-pressurized area.

[00019] In one ~~embodiment~~example, a valve assembly attached to a pipe or barrel is provided that inputs a liquid into the valve body after output of a liquid or slurry from the pipe or barrel but before said liquid or slurry reaches the valve needle.

[00020] In one ~~embodiment~~example, a valve assembly is provided wherein the valve body has a removable annular ring adjacent to a removable discharge ring in the discharge housing. In another ~~embodiment~~example, the discharge ring of the valve assembly is tapered.

INCORPORATION BY REFERENCE

[00021] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[00022] The novel features of the disclosure are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present disclosure will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the disclosure are utilized, and the accompanying drawings of which:

[00023] **FIG 1** is a diagram depicting the modified pressure valve assembly.

[00024] **FIG 2** is a diagram showing a longitudinal view of the valve and its housing.

[00025] **FIGS 3A and 3B** are diagrams depicting longitudinal views of the valve assembly from the top (**FIG 3A**) and side (**FIG 3B**).

[00026] **FIG 4** is a longitudinal drawing of the valve assembly from in a view from the top.

[00027] **FIG 5** is a larger drawing of section A seen in **FIG 4**.

[00028] **FIG 6** is a drawing of a cross section of the valve body without the valve needle.

CLAIMS

1. A valve assembly comprising:

a valve body having an input end, a discharge end, and a chamber formed therein in connection with the input end and the discharge end, the input end attachable to a tube with a fluid or slurry input that flows through the valve assembly;

a conical valve needle that has a cone with a wide end opposing to its conical tip and is axially displaceable in the chamber within the valve body; and

a housing attached to the discharge end of the valve body and enclosing the conical valve needle when the conical valve needle is disengaged with the valve body;

wherein the conical valve needle has a diameter at the wide end that is at least 4% larger than an inner diameter of the valve body at its discharge end.

2. The valve assembly of claim 1, wherein the valve body has an annular ring that sits in a recessed cavity on an internal surface of the valve body at the discharge end.

3. The valve assembly of claim 2, wherein the annular ring is replaceable.

4. The valve assembly of claim 2, wherein an internal surface of the annular ring aligns with the internal surface of the valve body.

5. The valve assembly of claim 2, wherein the conical valve needle sits at the annular ring when closed in the valve body.

6. The valve assembly of claim 1, wherein the housing comprises therein a detachable discharge ring that sits adjacent to the discharge end of the valve body.

7. The valve assembly of claim 6, wherein the discharge ring has a tapered shape.

8. The valve assembly of claim 1, wherein the valve body comprises nozzles for input of a liquid.

9. The valve assembly of claim 1, wherein the chamber of the valve body forms a part of a reaction zone with the tube for a biomass pretreatment process.

10. The valve assembly of claim 9, wherein the tube is an extruder.

11. The valve assembly of claim 10, wherein the extruder is a twin screw extruder.

12. The valve assembly of claim 1, wherein the valve assembly further comprises an actuator and a shaft, and wherein the conical valve needle is operably linked to ~~an~~ the actuator via ~~a~~ the shaft.

13. The valve assembly of claim 12, wherein the actuator maintains a pressure on the conical valve needle.

14. The valve assembly of claim 12, wherein the actuator is configured to maintain ~~maintains~~ a pressure of over 1,800 lbf on the conical valve needle.

~~15. The valve assembly of claim 12, wherein the actuator maintains a pressure of between 50,000 to 500,000 lbf on the valve needle.~~

~~16.~~15. The valve assembly of claim 1, wherein the valve body has a circular section at the discharge end, a circular collar at the input end that is smaller in inner diameter than the circular section at the discharge end, and an intercalary conical section therebetween.

~~17.~~16. The valve assembly of claim 1, wherein there is an annular space formed in the chamber between the conical valve needle and the valve body when the conical valve needle is closed on the valve body.

~~18. The valve assembly of claim 1, wherein the housing comprises a discharge pipe.~~

~~19.~~17. The valve assembly of claim 1, wherein an inner diameter of the housing at an end of the housing abutting the valve body is at least 7% larger than an inner diameter of the valve body at its discharge end.

~~20. The valve assembly of claim 1, wherein an inner diameter of the housing at an end of the housing abutting the valve body is about 7% larger than an inner diameter of the valve body at its discharge end.~~

~~21.~~18. The valve assembly of claim 1, wherein the cone of the conical valve needle is tapered in a range of from about 45 degrees to about 75 degrees.

~~22.~~19. The valve assembly of claim 1, wherein the cone of the conical valve needle is tapered about 45 degrees.

~~23.~~20. A conical valve needle for engagement with a valve body that comprises a valve needle that extends beyond the valve body into a discharge area when the valve is closed.

~~24. The valve needle of claim 23, wherein an annular ring is part of the valve body.~~

~~25. The valve needle of claim 24, wherein the valve needle seats downstream of the annular ring.~~

~~26. The valve needle of claim 24, wherein the annular ring is replaceable.~~

~~27. The valve needle of claim 23, wherein a housing is attached downstream to the valve body and contains a detachable discharge ring.~~

~~28. The valve needle of claim 23, wherein the valve body contains nozzles for the input of a liquid.~~

~~29. The valve needle of claim 23, wherein the valve needle seats when closed in the valve body at the discharge ring.~~

~~30. The valve needle of claim 23, that forms a part of a reaction zone with the tube.~~

~~31. The valve needle of claim 23, wherein the valve needle is attached to an actuator.~~

~~32. The valve needle of claim 31, wherein the actuator maintains a pressure on the valve needle.~~

~~33. The valve needle of claim 32, wherein the actuator maintains a pressure of over 1,800 lbf on the valve needle.~~

~~34. The valve needle of claim 33, wherein the pressure is between 50,000 to 500,000 lbf on the valve needle.~~

~~35. The valve needle of claim 23, wherein valve body is attached to an extruder.~~

~~36. The valve needle of claim 35, wherein the extruder is a twin screw extruder.~~

~~37. A valve assembly that becomes part of the reaction zone with a tube or pipe.~~

~~38. The valve assembly of claim 37, wherein the pipe or tube is an extruder.~~

~~39. The valve assembly of claim 38, wherein the extruder is a twin screw extruder.~~

~~40. The valve assembly of claim 39, wherein at least part of the contents of the extruder are under pressure.~~

~~41. The valve assembly of claim 39, wherein the pressurized zone extends into the valve assembly.~~

~~42. A valve assembly that has an increase in internal diameter between the end of the valve body where material is discharged and the diameter of the discharge housing.~~

~~43.~~21. A valve assembly comprising:

a valve body comprising a large circular section, an intercalary conical section, and a small circular collar containing one or more nozzles for liquid input, the valve body having a chamber formed therein that connects an input end and a discharge end of the valve body, wherein the small circular collar is smaller in inner diameter than the large circular section;

a valve needle axially displaceable within the chamber of the valve body; and

a housing attached to the discharge end of the valve body and enclosing the valve needle when the valve needle is disengaged with the valve body.

~~44. The valve assembly of claim 43, wherein the housing contains a removable discharge ring.~~

~~45. The valve assembly of claim 44, wherein the discharge ring is tapered.~~

~~46. The valve assembly of claim 43, wherein the valve body contains an annular ring.~~

~~47. The valve assembly of claim 46, wherein the annular ring is removable.~~

~~48. The valve assembly of claim 43, wherein there is an annular space formed in the chamber between the valve body and the valve needle when the valve needle is closed on the valve body.~~

~~49. The valve assembly of claim 43, wherein the nozzles for liquid input transfer water into the chamber.~~

~~50. The valve assembly of claim 43, wherein the nozzles for liquid input transfer a liquid other than water into the chamber.~~

~~51. The valve assembly of claim 50, wherein the liquid is selected from the group consisting of: an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof.~~

~~52. The valve assembly of claim 43, wherein an inner diameter of the housing at an end of the housing abutting the valve body is at least 7% larger than an inner diameter of the valve body at its discharge end.~~

~~53. The valve assembly of claim 43, wherein an inner diameter of the housing at an end of the housing abutting the valve body is about 7% larger than an inner diameter of the valve body at its discharge end.~~

~~54. The valve assembly of claim 43, wherein the valve needle has a cone with a wide end opposing to its conical tip.~~

~~55. The valve assembly of claim 54, wherein the cone is tapered in a range of from 45 degrees to 75 degrees.~~

~~56. The valve assembly of claim 54, wherein the cone is tapered about 45 degrees.~~

~~57. The valve assembly of claim 54, wherein the valve needle has a diameter at the wide end that is at least 4% larger than an inner diameter of the valve body at its discharge end.~~

~~58. The valve assembly of claim 54, wherein the valve needle has a diameter at the wide end that is about 4% larger than an inner diameter of the valve body at its discharge end.~~

~~59.~~22. A system for treating biomass through an extruder comprising:

(a) an extruder comprising one or more screws wherein an internal plug of biomass is formed due to action of the screws, thereby forming one end of a pressurized reaction zone;

(b) a means for supplying steam and chemicals to the reaction zone; and

(c) a valve assembly at an output end of the extruder that forms a downstream end of the reaction zone and adds a liquid to the reaction zone;

wherein the valve assembly is capable of rapidly discharging pressurized treated biomass into a non-pressurized discharge area.

~~60. The system of claim 59, wherein the biomass is selected from the group consisting of: silage, agricultural residues, com stover, bagasse, sorghum, nuts, nut shells, coconut shells, Distillers Dried Solubles, Distillers Dried Grains, Condensed Distillers Solubles Distillers Wet Grains, Distillers Dried Grains with Solubles, woody materials, sawdust, wood chips, timber slash, mill scrap, municipal waste, waste paper, recycled toilet papers, yard clippings, and energy crops such as poplars, willows, switchgrass, alfalfa, and prairie bluestem, non-woody plant matter, cellulosic material, lignocellulosic material, hemicellulosic material, carbohydrates, corn, sugar cane, grasses, switchgrass, high biomass sorghum, bamboo, corncobs, and peels and pits.~~

~~61. The system of claim 59, wherein the biomass is treated for less than 60, 55, 50, 45, 40, 35, 30, 25, 20, 19, 18, 17, 16, 15, 14, 13, 12, 10, 9, 8, 7, 6, 5, 4, 3, 2, or 1 second in the reaction zone.~~

~~62. The system of claim 59, wherein the temperature in the reaction zone is elevated to 50-500 °C, 75-400 °C, 100-350°C, 150-300°C, 200-250°C, 150-300°C, 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI.~~

63. The system of claim 59, wherein the chemical is an acid.

64. The system of claim 63, wherein the acid is sulfuric acid.

65. The system of claim 59, wherein the valve assembly comprises:

a valve body comprising a large circular section, an intercalary conical section, and a small circular collar containing one or more nozzles for liquid input, the valve body having a chamber formed therein that connects an input end and a discharge end of the valve body, wherein the small circular collar is smaller in inner diameter than the large circular section;

a valve needle axially displaceable within the chamber of the valve body; and

a housing attached to the discharge end of the valve body and enclosing the valve needle when the valve needle is disengaged with the valve body.

66. The system of claim 65, wherein the housing contains a removable discharge ring.

67. The system of claim 66, wherein the discharge ring is tapered.

68. The system of claim 65, wherein the valve body contains an annular ring.

69. The system of claim 68, wherein the annular ring is removable.

70. The system of claim 65, wherein there is an annular space formed in the chamber between the valve body and the valve needle when the valve needle is closed on the valve body.

71. The system of claim 65, wherein the nozzles for liquid input transfer water into the chamber.

72. The system of claim 65, wherein the nozzles for liquid input transfer a liquid other than water into the chamber.

73. The system of claim 72, wherein the liquid is selected from the group consisting of: an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof.

74. The system of claim 65, wherein an inner diameter of the housing at an end of the housing abutting the valve body is at least 7% larger than an inner diameter of the valve body at its discharge end.

75. The system of claim 65, wherein an inner diameter of the housing at an end of the

~~housing abutting the valve body is about 7% larger than an inner diameter of the valve body at its discharge end.~~

~~76. The system of claim 65, wherein the valve needle has a cone with a wide end opposing to its conical tip.~~

~~77. The system of claim 76, wherein the cone is tapered in a range of from 45 degrees to 75 degrees.~~

~~78. The system of claim 76, wherein the cone is tapered about 45 degrees.~~

~~79. The system of claim 76, wherein the valve needle has a diameter at the wide end that is at least 4% larger than an inner diameter of the valve body at its discharge end.~~

~~The system of claim 76, wherein the valve needle has a diameter at the wide end that is about 4% larger than an inner diameter of the valve body at its discharge end.~~