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 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 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 examples, the annular ring is replaceable. In some examples, an internal surface of the annular ring aligns with the internal surface of the valve body. In some examples, the valve needle sits at the annular ring when closed in the valve body. In some examples, the housing comprises therein a detachable discharge ring that sits adjacent to the discharge end of the valve body. In some examples, the discharge ring has a tapered shape. In some examples, the valve body comprises nozzles for input of a liquid. In some examples, the chamber of the valve body forms a part of a reaction zone with the tube for a biomass pretreatment process. In some examples, the tube is an extruder. In some examples, the extruder is a twin screw extruder. In some examples, the valve needle is operably linked to an actuator via a shaft. In some examples, the actuator maintains a pressure on the valve needle. In some examples, the actuator maintains a pressure of over 1,800 lbf on the valve needle. In some examples, the actuator maintains a pressure of between 50,000 to 500,000 lbf on the valve needle. In some 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 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 examples, the housing comprises a discharge pipe. In some 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 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 examples, the cone of the conical valve needle is tapered in a range of from about 45 degrees to about 75 degrees. In some examples, the cone of the conical valve needle is tapered about 45 degrees.

[0006] In another 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 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 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 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 example, the valve assembly housing contains a detachable discharge ring. In another example, the valve body contains nozzles for the input of a liquid. In a further example, the valve needle seats when closed in the valve body at the discharge ring. In one example, the valve assembly forms a part of a reaction zone with the tube. In a further example, the valve needle is attached to an actuator. In one 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 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 example, the tube attached to the valve assembly is an extruder. In a further example, the extruder is a twin screw extruder.

[00011] In another 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 example, an annular ring is part of the valve body. In another example, the valve needle seats downstream of the annular ring. In a further

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

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

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

[00014] In one example, a valve assembly is provided, wherein the pressurized zone of a tube or pipe or extruder extends into the valve assembly. In another 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 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 example the housing contains a removable discharge ring. In a further example, the discharge ring is tapered. In another example, the valve body contains an annular ring. In another example, the annular ring is removable. In another example, there is a space between the valve body and the valve needle when the valve needle is seated. In a further example, the nozzles for liquid input transfer water into the space between the valve body and the valve needle. In a further 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 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 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 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 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 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 example, the chemical is an acid. In a further 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 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 example, the system has a valve assembly wherein the housing contains a removable discharge ring. In a further example, the discharge ring of the valve assembly is tapered. In another example, the valve body of the valve assembly

contains an annular ring. In a further example, the annular ring is removable. In another example, the valve body contains a space between the valve body and the valve needle when the valve needle is seated. In another 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 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 example, the liquid comprises an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof.

[00018] In one 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 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 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 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 the actuator via 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 a pressure of over 1,800 lbf on the conical valve needle.

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.

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.

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.

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.

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

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.

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.

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.