PRESSURE VALVE PROCESSING

CROSS-REFERENCE

[0001] This application claims the benefit 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 system for pretreating a biomass comprising: an extruder comprising one or more screws, wherein an internal plug of the biomass is formed due to action of the one or more screws, thereby forming an upstream end

of a pressurized reaction zone for pretreatment of the biomass; and a valve assembly attached at an output

end of the extruder, wherein the valve assembly forms a downstream end of the reaction zone and adds a liquid to the reaction zone.

[0005] In another example, provided herein is a system for pretreating a biomass comprising: an extruder comprising one or more screws, wherein an internal plug of the biomass is formed due to action of the one or more screws, thereby forming an upstream end of a pressurized reaction zone for pretreatment of the biomass; and a valve assembly attached at an output end of the extruder, 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.

[0006] In some examples, 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, wood pellets, 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, high biomass sorghum, bamboo, corncobs, and peels and pits. In some examples, 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. In some examples, temperature in the reaction zone is elevated to 50-500 °C, 75-400 °C, 100-350°C, 150-300°C, 200-250°C, or 150-300°C, and pressure in the reaction zone is elevated to 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI. In some examples, the system further comprises a mean for supplying steam and one or more chemicals to the reaction zone. In some examples, the one or more chemicals comprise an acid. In some examples, the acid is sulfuric acid.

[0007] In some examples, 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. In some examples, the housing contains a removable discharge ring. In some examples, the discharge ring is tapered. In some examples, the valve body contains an annular ring. In some examples, the annular ring is removable. In some examples, 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. In some examples, the nozzles for liquid input transfer water into the chamber. In some examples, the nozzles for liquid input transfer a liquid other than water into the chamber. In some examples, 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. 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 valve needle has a cone with a wide end opposing to its conical tip. In some examples, the cone is tapered in a range of from 45 degrees to 75 degrees. In some examples, the cone is tapered about 45 degrees. In some examples, 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. In some examples, 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. In some examples, the extruder is a twin screw extruder. In some examples, the extruder has ports for adding steam and/or acid.

[0008] In another aspect, is the present disclosure refers to a method of pretreating a biomass through the system disclosed herein.

[0009] In yet another aspect, the present disclosure refers to a method of pretreating a biomass, the method comprising: conveying the biomass through an extruder from a feeder zone of the extruder to a reaction zone of the extruder, wherein the feeder zone and the reaction zone are separated by a biomass plug formed downstream of the input zone and upstream from the reaction zone; adding steam and/or a chemical to the biomass in the reaction zone to partially treat the biomass; conveying the partially-treated biomass into a valve assembly attached to an output end of the extruder, and treating the partially-treated biomass in the valve assembly, thereby producing a pretreated biomass; and discharging the pretreated biomass through the valve assembly.

[00010] In some examples of the method, the biomass is conveyed through the extruder at a velocity same as a velocity at which the partially-treated biomass is conveyed through the

valve assembly. In some examples, temperature in the reaction zone is elevated to 50-500 °C, 75-400 °C, 100-350°C, 150-300°C, 200-250°C, or 150-300°C, and pressure in the reaction zone is elevated to 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI. In some examples, 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, wood pellets, 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, high biomass sorghum, bamboo, corncobs, and peels and pits. In some examples, 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. In some examples, the chemical is selected from the group consisting of: an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof. In some examples, the extruder comprises one or more screws. In some examples, the extruder comprises two screws.

[00011] In another example, provided herein is a method of pretreating a biomass, the method comprising: conveying the biomass through an extruder from a feeder zone of the extruder to a reaction zone of the extruder, wherein the feeder zone and the reaction zone are separated by a biomass plug formed downstream of the input zone and upstream from the reaction zone; adding steam and/or a chemical to the biomass in the reaction zone to partially treat the biomass; conveying the partially-treated biomass into an extension compartment attached to an output end of the extruder, and treating the partially-treated biomass in the extension compartment, thereby producing a pretreated biomass.

[00012] In some examples, the method further comprising adding an acid at a downstream end of the extruder as the biomass exits the extruder. In some examples, the extension compartment is formed by a tube. In some examples, the extension compartment is formed by a vessel. In some examples, the extension compartment is formed by a valve assembly. In some examples, the extension compartment is capable of discharging the pretreated biomass in a continuous manner. In some examples, the extension compartment is capable of discharging the pretreated biomass in a semi-continuous manner. In some examples, the extension compartment is capable of discharging the pretreated biomass in batches. the biomass is conveyed through the extruder at a velocity same as a velocity at which the partially-treated biomass is conveyed through the extension compartment. In some

examples, the extension compartment is pressurized. In some examples, the extension compartment is equipped with one or more nozzles for liquid input. In some examples, the nozzles for liquid input transfer water into the chamber. In some examples, the nozzles for liquid input transfer a liquid other than water into the chamber. In some examples, 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. In some examples, temperature in the reaction zone is elevated to 50-500 °C, 75-400 °C, 100-350°C, 150-300°C, 200-250°C, or 150-300°C, and pressure in the reaction zone is elevated to 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI. In some examples, 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, wood pellets, 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, high biomass sorghum, bamboo, corncobs, and peels and pits. In some examples, 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. In some examples, the chemical is selected from the group consisting of: an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof. In some examples, the extruder comprises one or more screws. In some examples, the extruder comprises two screws.

[00013] In one example, a system for treating biomass through an extruder and a valve assembly 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 one or more chemicals to the reaction zone; a valve assembly attached 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 the valve assembly capable of rapidly discharging pressurized treated biomass into a non-pressurized discharge area.

[00014] In some examples, 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, wood pellets, 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, 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 another 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, or 150-300°C, and the pressure is elevated by steam to 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 another example, the acid is sulfuric acid. In a further example, the valve assembly comprises: a housing; 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.

[00015] In another example, there is a space between the valve body and the valve needle when the valve needle is seated. In one example, the nozzles for liquid input transfer water into the space between the valve body and the valve needle. In another example, the nozzles for liquid input transfer a liquid other than water into the space between the valve body and the valve needle. In one 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 one example, there is a method for treating a slurry or liquid in a pipe or barrel attached to a valve assembly, the method comprising: the pipe or barrel having a plug forming one end of a reaction zone; conveying a liquid or slurry through the pipe or barrel; having a valve assembly attached to the output end of the pipe or barrel forming the downstream end of the reaction zone while maintaining pressure in the reaction zone through the input of steam; adding a substance into the upstream end of the valve assembly as the liquid or slurry enters the valve assembly: and using the valve assembly to discharge the treated liquid or slurry into a non-pressurized area. In one example, the liquid or slurry comprises biomass. 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, wood pellets, 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, high biomass sorghum,

bamboo, corncobs, and peels and pits. In another 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.

[00017] 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, or 150-300°C, and the pressure is elevated by steam to 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI. In another example, the substance is an acid. In a further example, the acid is sulfuric acid.

[00018] In one example, a system is provided to extend a reaction zone downstream of an extruder, comprising: an extruder comprising a reaction zone section, wherein said extruder reaction zone section is attached to a downstream valve assembly comprising an adjacent inner space; wherein the reaction zone section in the extruder is combined with the adjacent inner space of the valve assembly to extend the reaction zone downstream of the extruder. In another example, the velocity of the materials moving through the reaction zone section of the extruder is kept constant with the velocity of the materials moving through the valve assembly.

[00019] In one example, the valve assembly has an annular ring that is part of the valve body. In another example, the annular ring is replaceable. In one example, the valve body contains nozzles for the input of a liquid. In one example, a valve needle seats at a discharge ring when closed in the valve body. 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.

[00020] In one example, the extruder is a twin screw extruder. In another example, the extruder has ports for adding steam and/or acid.

[00021] In one example, a method to extend a reaction zone downstream of an extruder is provided, the method comprising processing biomass in a reaction zone wherein the reaction zone extends from an extruder into an attached downstream valve assembly. In one example, the valve assembly comprises: a housing, a valve body further 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.

[00022] In one example, the housing contains a removable discharge ring. In another example, the discharge ring is tapered. In a further example, the valve body contains an annular ring. In a further example, the annular ring is removable. In one

example, there is a space between the valve body and the valve needle when the valve needle is seated. In another 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 another example, the liquid in the nozzles is selected from the group consisting of: an acid, a base, an alcohol, a ketone, an aldehyde, a solvent, or a combination thereof. In another example, the liquid is an acid. In a further example, the acid is sulfuric acid. In another example, steam and one or more chemicals are added to the reaction zone of the extruder. In a further 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, or 150-300°C. The pressure is elevated by steam to 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI. In another example, the velocity is kept constant throughout the reaction zone.

[00023] In one example, a method of processing biomass is provided comprising: conveying biomass through an extruder wherein the extruder is divided into two zones, an input zone and a reaction zone, separated by a biomass plug formed downstream of the input zone and upstream from the reaction zone; adding steam and/or a chemical to biomass in the reaction zone to partially treat the biomass; conveying the partially-treated biomass into an attached valve assembly for a time to continue treatment; and discharging the biomass through the valve assembly. In another example, the velocity of the biomass being conveyed is the same in the extruder and in the valve assembly. In a 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, or 150-300°C. The pressure is elevated by steam to 50-1000 PSI, 100-750 PSI, 200-600 PSI, 300-500 PSI or 350-450 PSI. In a further 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, wood pellets, 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, high biomass sorghum, bamboo, corncobs, and peels and pits. In one 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 second in the reaction zone. In another example, the chemical

CLAIMS

1. A system for pretreating a biomass comprising:

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

(b) a valve assembly attached at an output end of the extruder, wherein the valve assembly forms a downstream end of the reaction zone and adds a liquid to the reaction zone.

2. The system of claim 1, wherein the system further comprises a mean for supplying steam and one or more chemicals to the reaction zone.

3. The system of claim 2, wherein the one or more chemicals comprise an acid.

4. The system of claim 3, wherein the acid is sulfuric acid.

5. The system of claim 1, 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.

6. The system of claim 5, wherein the housing contains a removable discharge ring.

7. The system of claim 6, wherein the discharge ring is tapered.

8. The system of claim 5, wherein the valve body contains an annular ring.

9. The system of claim 8, wherein the annular ring is removable.

10. The system of claim 5, 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.

11. The system of claim 5, 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.

12. The system of claim 5, 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.

13. The system of claim 5, wherein the valve needle has a cone with a wide end opposing to its conical tip.

14. The system of claim 13, wherein the cone is tapered in a range of from 45 degrees to 75 degrees.

15. The system of claim 13, wherein the cone is tapered about 45 degrees.

16. The system of claim 13, 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.

17. The system of claim 13, 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.

18. The system of claim 1, wherein the extruder is a twin screw extruder.

19. A method of pretreating a biomass through the system of any one of claims 1-18.

20. A method of pretreating a biomass, the method comprising:

(a) conveying the biomass through an extruder from a feeder zone of the extruder to a reaction zone of the extruder, wherein the feeder zone and the reaction zone are separated by a biomass plug formed downstream of the input zone and upstream from the reaction zone;

(b) adding steam and/or a chemical to the biomass in the reaction zone to partially treat the biomass;

(c) conveying the partially-treated biomass into a valve assembly attached to an output end of the extruder, and treating the partially-treated biomass in the valve assembly, thereby producing a pretreated biomass; and

(d) discharging the pretreated biomass through the valve assembly.