extruders but it cannot be used on other extruder types and is limited in the degree of restriction it can produce.

[0005] There is accordingly a need in the art for improved extruder injector assemblies that can operate efficiently on high-output, biomass extruder systems without the design and plugging problems of conventional systems.

SUMMARY

[0006] Provided herein is a system for introducing one or more additives into materials, the system comprising: an assembly of injectors, wherein the injectors comprises internal bores of a diameter ranging from 2 to 6 mm; a manifold for controlling flows of substances in said assembly of injectors; valves incorporated into the manifold for each injector to independently control the flows of substances in the injector; and a supply of an additive. In some examples, the additive is a liquid or a steam. In some examples, the additive is water. In some examples, the additive is an acid. In some examples, the additive is a steam and wherein the steam is at a pressure of about 80-600 psi. In some examples, the additive is a steam and wherein the steam is at a pressure of about 150 psi. In some examples, the additive is a steam and wherein the steam is at a pressure of about 200 psi. In some examples, the additive is a steam and wherein the steam is at a pressure of about 250 psi. In some examples, the additive is a steam and wherein the steam is at a pressure of about 300 psi.

[0006a] In one aspect, the present disclosure refers to a system for introducing one or more additives into materials, the system comprising: an assembly of injectors, wherein the injectors comprises internal bores of a diameter ranging from 2 to 6 mm; a manifold for controlling flows of substances in said assembly of injectors; valves incorporated into the manifold for each injector to independently control the flows of substances in the injector; and a supply of an additive.

[0007] In some examples, the materials comprise a biomass. In some examples, the materials comprise a biomass, and wherein the materials are within a conduit. In some examples, the conduit comprises an extruder. In some examples, the conduit further comprises a discharge valve. In some examples, the internal bores of the injectors have a diameter of about 2 mm. In some examples, the internal bores of the injectors have a diameter of about 2.5 mm. In some examples, the internal bores of the injectors have a diameter of about 3 mm. In some examples,

the internal bores of the injectors have a diameter of about 3.5 mm. In some examples, the internal bores of the injectors have a diameter of about 4 mm. In some examples, the internal bores of the injectors have a diameter of about 4.5 mm. In some examples, the internal bores of the injectors have a diameter of about 5 mm. In some examples, the internal bores of the injectors have a diameter of about 5.5 mm. In some examples, the internal bores of the injectors have a diameter of about 6 mm.

[0008] In some examples, the assembly of injectors comprises 2 or more injectors. In some examples, the assembly of injectors comprises 4 or more injectors. In some

examples, the assembly of injectors comprises 6 or more injectors. In some examples, the assembly of injectors comprises 8 or more injectors. In some examples, the assembly of injectors comprises 10 or more injectors. In some examples, the assembly of injectors comprises 12 or more injectors. In some examples, the assembly of injectors comprises 14 or more injectors. In some examples, the assembly of injectors comprises 16 or more injectors. In some examples, the materials consist of biomass within a reaction zone.

[0009] In another aspect, the present disclosure refers to a method of injecting liquid or steam into an extruder barrel or a valve body comprising: providing a plurality of injection ports, wherein the injection ports penetrate an outer wall of the extruder barrel or an outer wall of the valve body; introducing injectors into the plurality of injection ports; injecting steam into said extruder barrel or said valve body to maintain a pressure between 150 to 800 psi in said extruder barrel or said valve body; and injecting liquid into said extruder barrel or valve body.

[00010] In yet another aspect, the present disclosure refers to a method of injecting liquid and steam into an extruder barrel or a valve body comprising: providing a plurality of injection ports, wherein the injection ports penetrate the extruder barrel or the valve body; introducing injectors into the plurality of injection ports; and injecting liquid and steam into said extruder barrel or said valve body to maintain a pressure between 150 to 800 psi in said extruder barrel or said valve body.

[00011] In some examples, the injector comprises a nozzle bore with a diameter between 2-6 mm. In some examples, the injector comprises a nozzle bore with a diameter between 2-4 mm. In some examples, the injector comprises a nozzle bore with a diameter between 2-3 mm. In some examples, the injector comprises a nozzle bore with a diameter of about 2 mm. In some examples, for pretreating at least one dry ton of biomass per day, the method further comprising: feeding the biomass at a rate of at least one dry metric ton (MT) of biomass per day into an extrusion system comprising a barrel, wherein the barrel comprises an inner chamber comprising a feeder zone and a reaction zone, wherein the extrusion system is constructed and arranged such that: a steam impervious plug is formed by compacting the biomass in a high pressure zone separating the feeder zone and the reaction zone, and an assembly of steam injectors having an internal nozzle bore diameter of 6 mm or less provide pressure and high temperatures to the reaction zone.

[00012] Provided herein is an extruder system comprising an assembly of one or more injectors, wherein the injectors comprise a nozzle bore with a diameter of 6 mm or less. In some examples, the injectors provide steam at a pressure of 150-800 psi to the extruder bore. In some examples, the injectors have an internal bore diameter of 4 mm or less. In some examples, the injectors have an internal bore diameter of 2 mm or less. In some examples, the extruder system comprises at least 2 assemblies of injectors, at least 3

assemblies of injectors, or at least 4 assemblies of injectors. In some examples, internal bores of the injectors have a diameter of about 2 mm. In some examples, internal bores of the injectors have a diameter of about 2.5 mm. In some examples, internal bores of the injectors have a diameter of about 3 mm. In some examples, internal bores of the injectors have a diameter of about 3.5 mm. In some examples, internal bores of the injectors have a diameter of about 4 mm. In some examples, internal bores of the injectors have a diameter of about 4.5 mm. In some examples, internal bores of the injectors have a diameter of about 5 mm. In some examples, internal bores of the injectors have a diameter of about 5.5 mm. In some examples, internal bores of the injectors have a diameter of about 6 mm. In some examples, the assembly of one or more injectors comprises 2 or more injectors. In some examples, the assembly of one or more injectors comprises 4 or more injectors. In some examples, the assembly of one or more injectors comprises 6 or more injectors. In some examples, the assembly of one or more injectors comprises 8 or more injectors. In some examples, the assembly of one or more injectors comprises 10 or more injectors. In some examples, the assembly of one or more injectors comprises 12 or more injectors. In some examples, the assembly of one or more injectors comprises 14 or more injectors. In some examples, the assembly of one or more injectors comprises 16 or more injectors.

[00013] Provided herein is an extruder system comprising a barrel section having spiral or concentric ports for an assembly of injector nozzles. In some examples, the barrel section comprises at least 4 ports. In some examples, the barrel section comprises at least 6 ports. In some examples, the barrel section comprises at least 8 ports. In some examples, the barrel section comprises at least 10 ports. In some examples, the barrel section comprises at least 12 ports. In some examples, the barrel section comprises at least 14 ports. In some examples, the barrel section comprises at least 16 ports. In some examples, the extruder system comprises two or more barrel sections. In some examples, the barrel section is interchangeable with other barrel sections. In some examples, the spiral or concentric ports are perpendicular to the barrel section. In some examples, the injectors are predisposed to inject 30-50% steam per dry weight of material.

[00014] Disclosed herein is a system for introducing one or more additives into materials, the system comprising: at least one assembly of injectors with internal bores of a diameter ranging from 2 to 6 mm; a manifold for controlling the flow of substances in said assembly; valves

incorporated into the manifold for each injector to independently control the flow of substances in the injector; and a supply of at least one additive. In some examples, the additive is a liquid or steam. In another example, the additive is water or an acid. In other examples, the additive is steam at a pressure of 80-600 psi. In other examples, the additive is steam at

a pressure of 80-600 psi. In other examples, the additive is steam at a pressure of 150 psi. In other examples, the additive is steam at a pressure of 200 psi. In other examples, the additive is steam at a pressure of 250 psi. In other examples, the additive is steam at a pressure of 300 psi. In one example, the materials consist of biomass in a conduit. In another example, the conduit is an extruder. In another example, the conduit comprises an extruder and a discharge valve.

[00015] Also disclosed herein is the system described *supra* wherein the internal bores of the injectors have a diameter of 2 mm, or 2.5 mm, or 3 mm, or 3.5 mm, or 4 mm, or 4.5 mm or 5 mm, or 5.5 mm, or 6 mm. Some examples further comprise the assembly consisting of 2 or more injectors, 4 or more injectors, 6 or more injectors, 8 or more injectors, 10 or more injectors, 12 or more injectors, 14 or more injectors, or even 16 or more injectors. In another example, the materials consist of biomass within a reaction zone.

[00016] Also disclosed herein are methods of injecting liquid or steam into an extruder barrel or a valve body comprising: having a plurality of injection ports penetrate the outer wall of the extruder barrel or outer valve wall to its bore; including injectors into the injection ports; injecting steam into said extruder barrel or valve to maintain the pressure between 150 to 800 psi in the conduit; and injecting liquid into said extruder barrel or valve.

[00017] In a further example, methods are disclosed of injecting liquid and steam into an extruder barrel or a valve body comprising: having a plurality of injection ports penetrate the extruder barrel or valve body to its bore; including injectors into the injection ports; and injecting liquid and steam into said extruder barrel or valve to maintain the pressure between 150 to 800 psi inside said zone.

[00018] In some examples, the injector nozzle bore diameter is between 2-6 mm. In some examples the injector nozzle bore diameter is between 2-4 mm. In other examples, the injector nozzle bore diameter is between 2-3 mm. In another example, the injector nozzle bore diameter is 2 mm.

[00019] Also disclosed are methods for pretreating at least one dry ton of biomass per day, the method comprising: feeding the biomass at a rate of at least one dry metric ton (MT) of biomass per day into an extrusion system comprising a barrel defining an inner chamber comprising a feeder zone and a reaction zone, wherein the extrusion system is constructed and arranged such that: a steam impervious plug is formed by compacting the biomass in a high pressure zone separating the feeder zone and the reaction zone, and at least one assembly of steam injectors

having an internal nozzle bore diameter of 6 mm or less provide pressure and high temperatures to the reaction zone.

[00020] Also disclosed is an extruder system having at least one assembly of one or more injectors having an internal nozzle bore diameter of 6 mm or less. In some examples, the injectors provide steam at a pressure of 150-800 psi to the extruder bore. In some examples, the injectors have an internal bore diameter of 4 mm or less. In other examples, the injectors have an internal bore diameter of 2 mm or less.

[00021] In some examples, the system consists of at least 2 assemblies of injectors, at least 3 assemblies of injectors, or at least 4 assemblies of injectors. In another example, the internal bores of the injectors have a diameter of 2 mm. In another example the internal bores of the injectors have a diameter of 2.5 mm, or 3 mm, or 3.5 mm, or 4 mm, or 4.5 mm, or 5 mm, or 6mm.

[00022] In some examples the assembly consists of 2 or more injectors. In some examples, the assembly consists of 4 or more injectors. In some examples, the assembly consists of 6 or more injectors. In some examples, the assembly consists of 8 or more injectors. In some examples, the assembly consists of 10 or more injectors. In some examples, the assembly consists of 12 or more injectors. In some examples, the assembly consists of 14 or more injectors. In some examples, the assembly consists of 16 or more injectors.

[00023] Also disclosed herein is an extruder system comprising at least one barrel section having spiral or concentric ports for an assembly of injector nozzles. In some examples, the barrel section has at least 4 ports. In other examples, the barrel section has at least 6 ports. In some examples, the barrel section has at least 8 ports. In some examples, the barrel section has at least 10 ports. In further examples, the barrel section has at least 12 ports. In another example, the barrel section has at least 14 ports. In some examples, the barrel section has at least 16 ports.

[00024] In some examples, the extruder system comprises at least two barrel sections. In some examples, the barrel section is interchangeable with other barrel sections. In some examples, the spiral or concentric ports are perpendicular to the barrel section.

[00025] Also disclosed herein is an extruder system wherein the injectors are predisposed to inject 30-50% steam per dry weight of material.

INCORPORATION BY REFERENCE

[00026] 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.

CLAIMS

1. A system for introducing one or more additives into materials, the system comprising:
    a. an assembly of injectors, wherein the injectors comprise internal bores of a diameter ranging from 2 to 6 mm;
    b. a manifold for controlling flows of substances in said assembly of injectors;
    c. valves incorporated into the manifold for each injector to independently control the flows of substances in the injector; and
    d. a supply of an additive.
2. The system of claim 1, wherein the additive is a liquid or a steam.
3. The system of claim 1, wherein the additive is water.
4. The system of claim 1, wherein the additive is an acid.
5. The system of claim 1, wherein the additive is a steam and wherein the steam is at a pressure of about 80-600 psi.
6. The system of claim 1, wherein the additive is a steam and wherein the steam is at a pressure of about 150 to about 300 psi.
7. The system of claim 1, wherein the materials comprise a biomass.
8. The system of claim 1, wherein the system further comprises a conduit for containing the materials.
9. The system of claim 8, wherein the conduit comprises an extruder.
10. The system of claim 9, wherein the conduit further comprises a discharge valve.
11. The system of claim 1, wherein the internal bores of the injectors have a diameter of about 2 to about 4 mm.
12. The system of claim 1, wherein the internal bores of the injectors have a diameter of about 2 mm.
13. The system of claim 1, wherein the assembly of injectors comprises 2 or more injectors.
14. The system of claim 1, wherein the assembly of injectors comprises 16 or more injectors.
15. A method of injecting liquid or steam into an extruder barrel or a valve body comprising:
    a. providing a plurality of injection ports, wherein the injection ports penetrate an outer wall of the extruder barrel or an outer wall of the valve body or both;
    b. introducing injectors into the plurality of injection ports;

c. injecting steam into said extruder barrel or said valve body to maintain a pressure between 150 to 800 psi in said extruder barrel or said valve body; and

d. injecting liquid into said extruder barrel or valve body.

16. A method of injecting liquid and steam into an extruder barrel or a valve body comprising:

a. providing a plurality of injection ports, wherein the injection ports penetrate the extruder barrel or the valve body;

b. introducing injectors into the plurality of injection ports; and

c. injecting liquid and steam into said extruder barrel or said valve body to maintain a pressure between 150 to 800 psi in said extruder barrel or said valve body.

17. An extruder system comprising an assembly of one or more injectors, wherein the injectors comprise a nozzle bore with a diameter of 6 mm or less.

18. An extruder system comprising a barrel section having spiral or concentric ports for an assembly of injector nozzles.

19. An extruder comprising:

(1) a barrel, wherein the barrel comprises an inner chamber comprising a feeder zone and a reaction zone, wherein the extruder is constructed and arranged such that a steam impervious plug is formed by compacting the biomass in a high pressure zone separating the feeder zone and the reaction zone;

(2) a discharge valve body at a discharge end of the barrel, wherein the barrel further comprises a plurality of injection ports that penetrate an outer wall of the barrel, or the valve body comprises a plurality of injection ports that penetrate an outer wall of the valve body, or both; and

(3) the system of claim 1, wherein the injectors are placed into the plurality of injection ports.

20. The extruder of claim 19, wherein the barrel comprises the plurality of injectors organized in spiral or circular patterns about the barrel.

21. The extruder of claim 20, wherein the plurality of injectors are perpendicular to the barrel.

22. The extruder of claim 20, wherein one or more of the injectors are predisposed to inject 30-50% steam per dry weight of materials in the barrel.