A method and apparatus is provided for use in a fixed-bed gasification system for the disengagement of gas and the removal of ash and charcoal. In one example, the invention includes an auger system, a water seal system, and a gas disengagement system. The gas disengagement mechanism prevents plugging and blinding of the gas offtake system and simultaneously limits particulate entrainment in the gas produced by the gasifier.
CHARCOAL/ASH REMOVAL SYSTEM FOR A DOWNDRAFT GASIFIER AND ASSOCIATED METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119 to co-pending commonly owned U.S. provisional patent application Ser. No. 60/947,545, attorney docket number EER.P0036P, filed on Jul. 2, 2007 entitled "CHARCOAL/ASH REMOVAL SYSTEM FOR A DOWNDRAFT GASIFIER", which is incorporated by reference herein.

FIELD OF THE INVENTION

[0002] This invention relates to fixed-bed gasification systems. In particular, this invention is drawn to gasification systems that remove charcoal and ash from a fixed bed of solids, and that are simple, robust, and cost-effective.

BACKGROUND OF THE INVENTION

[0003] Energy conversion devices, such as gasifiers, designed to convert solid fuel to heat and power, are significant to the world's energy infrastructure. A gasifier is operated by limiting the air required for complete combustion in order to primarily produce a low-Btu gas comprised of hydrogen, carbon monoxide, methane, carbon dioxide, and nitrogen. Gasifiers are common within the petroleum refining industry and employ a high-pressure letdown system for ash removal.

[0004] Gasifiers and combustors are typically designed to process coal, biomass, or waste products. Spent solids are produced in the form of ash or charcoal. The hot, dry, dusty material requires removal from the boiler or gasifier. Wet systems prove useful to quench the hot material and prevent dust entrainment. In addition, wet systems can be utilized to form an airtight seal and avoid the maintenance and expense of valves or lock hoppers relative to process requirements. With biomass gasifiers, in particular, it would be desirable to have a relatively simple way to remove charcoal, while maintaining a seal to prevent the loss of gas or infiltration of air to the gas-producing system.

[0005] Many techniques have been employed to remove solids from various processes. One problem with many systems, is that the techniques do not provide all of the desirable features of a fixed-bed gasification process. It is desired that fixed-bed gasifiers have the following features: 1) minimized particle entrainment into the product gas, 2) disengagement of the product gas from the fixed bed, 3) prevention of gas exhaustion manifold blinding or plugging, 4) limited disturbance of the fixed bed, 5) ability to handle metal objects and ash clinkers, 6) airtight seal of the gasifier, 7) dust mitigation of the solids discharge, and 8) fire prevention of hot charcoal discharged from the process. No system currently addresses all of these desirable features.

[0006] Typical examples of removal systems include systems designed for combustion and gasification processes. Examples include wet removal processes for hot ash or slag from coal boilers and charcoal removal from gasification systems. Some systems provide examples of wet removal processes that are limited to removal of the solids but do not address gas offtake systems. For example, U.S. Pat. No. 4,534,299 discloses a mechanism for wet ash removal from a boiler, including a means to catch and convey wet ash from the boiler and subsequently separate it. U.S. Pat. No. 4,321,876 provides a means of wet ash removal from a boiler, including a means of separating the solids from the wet media, where the wet media includes a stagnant pool of fluid.

[0007] Other examples exist for solid removal systems designed for coal gasifiers. For example, U.S. Pat. No. 3,571,636 provides a method of concentrating coal lines and re-injecting the carbon-containing mixture to a gasifier. However, this process is not a simple extraction and disposal technique, but rather a complicated high-pressure re-injection technique for a large-scale coal gasifier. U.S. Pat. No. 4,738,687 provides a technique for wet removal of residue from a pressurized gasifier. The technique includes an auger mechanism and spring designed for discharge from a pressurized vessel, but does not include a water tight seal.

[0008] The following examples show various systems for charcoal removal from gasifiers that are subject to problems with particulate entrainment, exhaust manifold fouling, dust, spontaneous ignition of spent charcoal, and process sealing issues, although none of the examples provide for a means of wet removal. U.S. Pat. No. 4,601,730 provides a method for air supply and ash removal from a biomass gasifier, including the use of mechanical conveyors. However, in that example, discharged residue must reside in a fixed container to store and cool prior to removal. U.S. Pat. No. 6,913,632 discloses a biomass gasifier with a dry solids removal system. This example is representative of biomass gasifiers but does not include wet removal systems.

[0009] WO Patent No. 2006/087587 A1 discloses a gasifier with a screw auger for removing ash and waste material that fall into the screw auger tube. The material within the auger serves as a seal. However, this configuration prevents gas disengagement and does not provide a water tight seal.

SUMMARY OF THE INVENTION

[0010] A system of the invention is provided for disengaging gas and removing charcoal and ash in a fixed-bed gasification system including a conveying system configured to be disposed below a gasifier for conveying charcoal and ash away from the gasifier, a vertical gas discharge port in communication with the conveying system, and a water seal in communication with the discharge port for preventing gas from passing through the water seal.

[0011] Another embodiment of the invention provides a method of disengaging gas and removing charcoal and ash in a fixed-bed gasifier including providing a conduit disposed generally below the gasifier, and extending away from the gasifier, conveying charcoal and ash away from the gasifier through the conduit, forming a vertical gas discharge port in the conduit, allowing gases produced by the gasifier to exit the gasifier, and sealing an end of the conduit with a water seal for preventing gas from passing through the water seal.

[0012] One embodiment includes a gas discharge system for a fixed-bed gasification system having a gasifier and an auger system for conveying charcoal and ash away from the gasifier, the gas discharge system including a discharge port extending upward from the auger system for allowing gases produced by the gasifier to exit the gasifier.

[0013] Other features and advantages of the present invention will be apparent from the accompanying drawings and from the detailed description that follows below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements and in which:
FIG. 1 is a diagram of an example of a gasifier having a removal system.

FIG. 2 is an isometric diagram of an example of a complete gasification and removal system.

DETAILED DESCRIPTION

There is a need for improved techniques for removal of solids from gasifiers, including gas disengagement mechanisms designed to prevent plugging and binding of gas offtake systems, while simultaneously limiting particulate entrainment in gas produced from the gasifier. It is also desired that such a mechanism also include 1) limited disturbance of the fixed bed, 2) the ability to handle metal objects and ash clinkers, 3) an airtight seal of the gasifier, 4) dust mitigation of the solids discharge, and 5) fire prevention of hot charcoal discharged from the process.

The present invention provides a simple and effective solution for removal of solids and for gas disengagement from a fixed-bed gasifier. The present invention provides a novel means for removing hot solids from the discharge end of the process, while eliminating plugging and binding of the exhaust gas manifold and limiting particulate entrainment into the produced gas.

One example of an apparatus of the present invention includes a vertical disengagement gas outlet, an auger system, and discharge to a water-sealed tank. This example provides a method to prevent exhaust gas manifold fouling and limits particulate entrainment in the gas using a robust automated solids removal system. One novel feature is the vertical arrangement and low velocity of the gas discharge, which prevents fouling of the exhaust manifold and limits particulate entrainment. The device also includes a single, double, or multiple-auger system for robust material handling, and a water seal to prevent dust and spontaneous ignition of the spent charcoal.

The present invention provides an apparatus and method designed to disengage gas from a fixed-bed gasifier and remove charcoal and ash. FIG. 1 is a diagram of a fixed-bed gasifier 10. The gasifier 10 includes a conical shaped combustion chamber 12 formed by an outside wall 14 and a lower wall 16. The upper end of the combustion chamber 12 has a closable top 18, which can be used to introduce fuel, as needed. A plurality of tuyeres 20 are formed around the periphery of the combustion chamber 12. During operation of the gasifier, air is injected into the tuyeres to provide combustion air. Also, the tuyeres 20 are configured to inject the combustion air in directions to provide a desired flow through the gasifier. The lower wall 16 slopes downward toward an opening 22 that leads top a cylindrical tube 24. During operation, charcoal exits the gasifier under gravity through circular opening 22.

Below the tube 24 is a conveying system 26. In the example shown, the conveying system includes a housing 27 containing one or more augers 28. The housing 27 forms a conduit between the gasifier 10 and the water seal (described below). Multiple augers 28 may be arranged side-by-side in an overlapping manner, as one skilled in the art would understand. Other auger arrangements are also possible, such as vertical and/or diagonal arrangements. The auger 28 is used to break clinkers and also provides a way to convey materials away from the gasifier, such as nails and bolts that may enter the gasifier without jamming the removal mechanisms.

The opposite end of the conveying system 26 forms a discharge port 30, where charcoal and ash are discharged into a water tank 32. The discharge port 30 extends into the water in the water tank 32, forming an airtight water seal that maintains a seal between the gasifier and the atmosphere. The water in the water tank 32 mitigates dust from the charcoal and eliminates the potential for spontaneous ignition of the hot solids.

The present invention also provides a gas disengagement system, whereby the gas disengagement system prevents plugging and binding of the gas offtake system and simultaneously limits particulate entrainment in the gas produced from the gasifier. A gas discharge port 34 is formed in the upper side of the housing 27 of the conveying system 26 and extends upward. Gases produced by the gasifier exit the system through the gas discharge port 34. The gas discharge port 34 is vertical and provides a low-velocity zone for gas to disengage from the solids to minimize particulate entrainment.

FIG. 2 is an isometric view of the fixed-bed gasifier 10. The gasifier 10 shown in FIG. 2 includes the combustion chamber 12, the conveying system 26, the discharge port 30, and gas discharge port 34. The water tank and water seal are not shown in FIG. 2.

Generally, the present invention operates as follows. Solid fuel is loaded into the combustion chamber 12 via the top 18 of the gasifier 10. One or more igniters (not shown) ignite the solid fuel, while air needed to combust the fuel is injected into the combustion chamber. The conditions (air flow, pressures, temperatures, etc.) desired to achieve ideal gasification conditions can be controlled in any desired manner, as one skilled in the art would understand. As the fuel burns, the fuel will form charcoal and ash, which falls through the tube 24, into the conveying system 26. The auger(s) 28 convey the charcoal and ash to the discharge port 30, where it will fall into the water tank 32. The gas produced by the gasifier 10 exits the gas discharge port 34. Due to the vertical configuration of the gas discharge port 34, the gas discharge port will tend not to plug.

In the preceding detailed description, the invention is described with reference to specific exemplary embodiments thereof. Various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the claims. The specific and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A system for disengaging gas and removing charcoal and ash in a fixed-bed gasification system comprising:
   - a conveying system configured to be disposed below a gasifier for conveying charcoal and ash away from the gasifier;
   - a vertical gas discharge port in communication with the conveying system; and
   - a water seal in communication with the discharge port for preventing gas from passing through the water seal.
2. The system of claim 1, wherein the conveying system includes an auger.
3. The system of claim 1, wherein the conveying system includes two or more augers.
4. The system of claim 1, wherein the water seal further comprises a water tank.
5. The system of claim 1, wherein the water seal further comprises a water tank.
6. The system of claim 1, wherein the vertical discharge port extends upward from the conveying system.
7. The system of claim 1, wherein the water seal is configured to provide an air tight seal between the gasifier and the atmosphere.

8. A method of disengaging gas and removing charcoal and ash in a fixed-bed gasifier comprising:
   providing a conduit disposed generally below the gasifier, and extending away from the gasifier;
   conveying charcoal and ash away from the gasifier through the conduit;
   forming a vertical gas discharge port in the conduit, allowing gases produced by the gasifier to exit the gasifier; and
   sealing an end of the conduit with a water seal for preventing gas from passing through the water seal.

9. The method of claim 8, wherein conveying charcoal and ash away from the gasifier through the conduit further comprises using an auger to convey the charcoal and ash.

10. The method of claim 8, wherein conveying charcoal and ash away from the gasifier through the conduit further comprises using two or more augers to convey the charcoal and ash.

11. The method of claim 8, wherein sealing an end of the conduit with a water seal further comprises configuring the conduit to extend into a water tank.

12. The method of claim 8, further comprising configuring the vertical discharge port to extend upward from the conduit.

13. The method of claim 8, wherein the water seal provides an air tight seal between the gasifier and the atmosphere.

14. A gas discharge system for a fixed-bed gasification system having a gasifier and an auger system for conveying charcoal and ash away from the gasifier, the gas discharge system comprising:
   a discharge port extending upward from the auger system for allowing gases produced by the gasifier to exit the gasifier.

15. The gas discharge system of claim 14, further comprising a water seal for sealing an end of the auger system.

16. The gas discharge system of claim 14, wherein the water seal further comprises a water tank.

17. The gas discharge system of claim 14, wherein the auger system includes two or more augers.

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