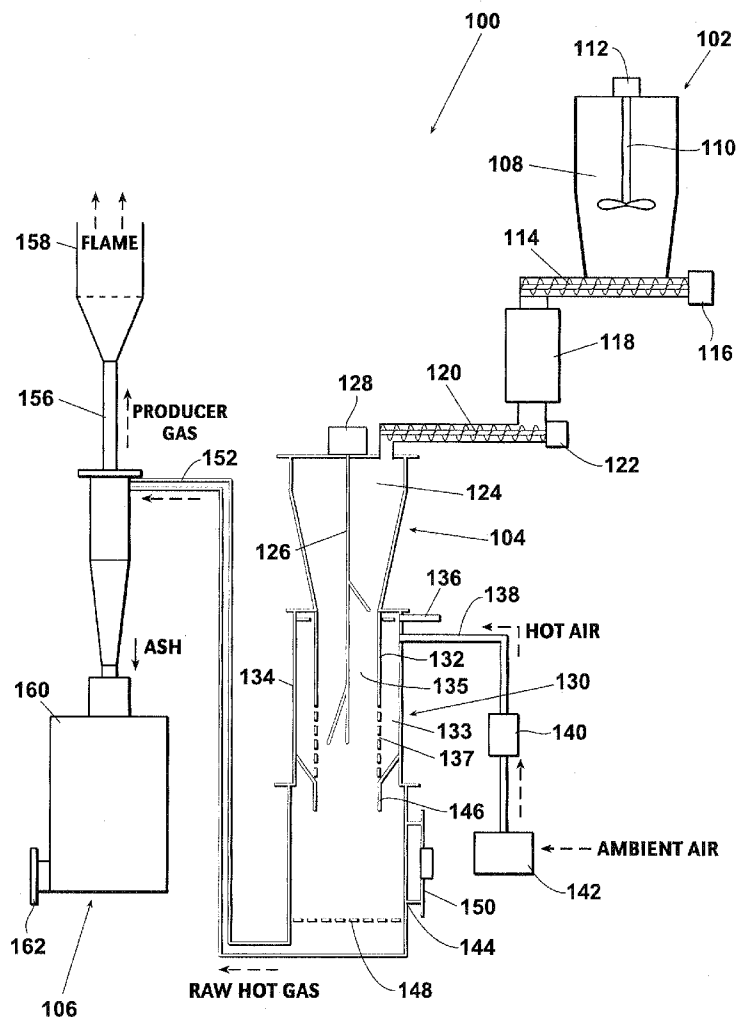




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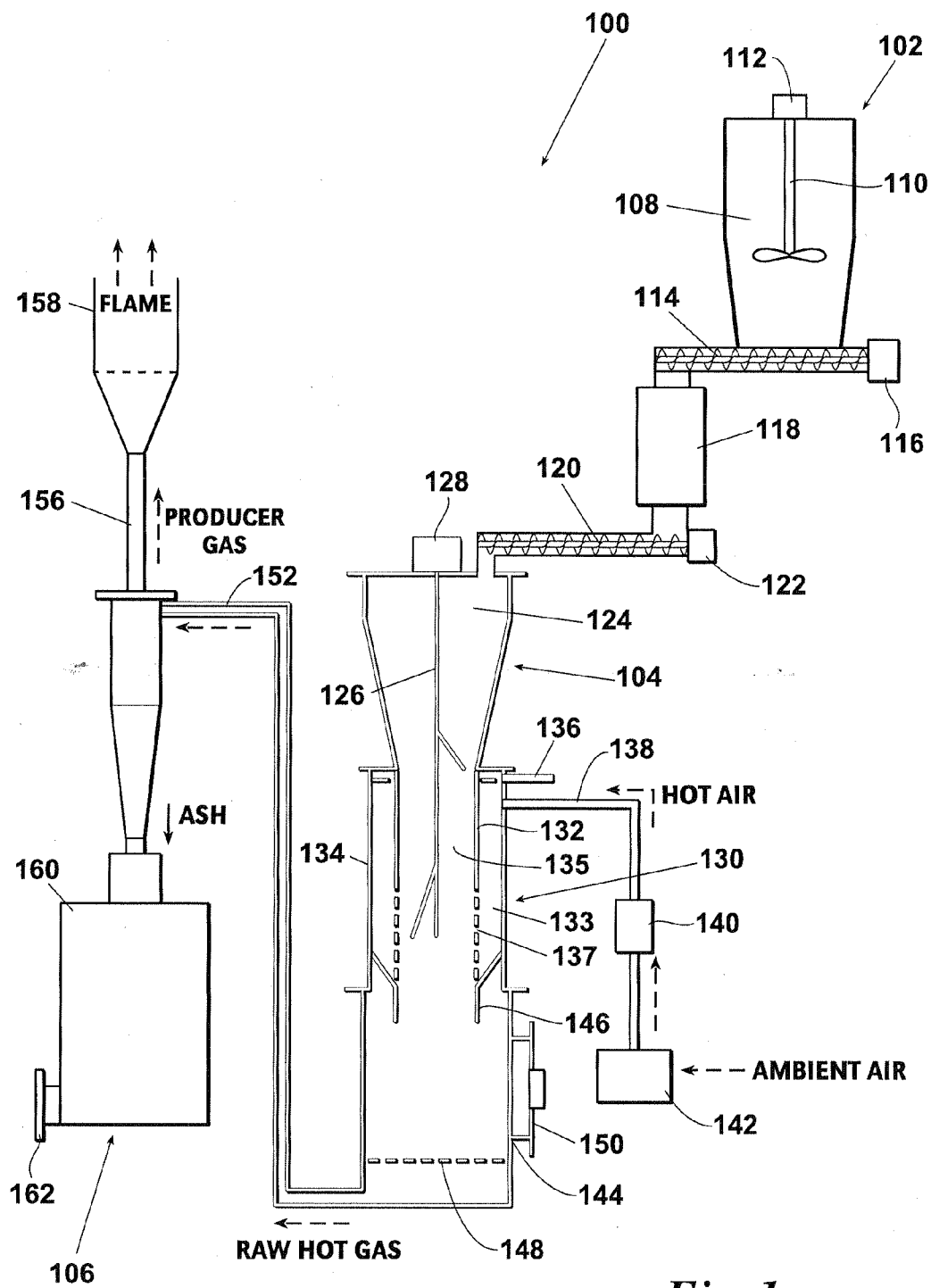


Fig. 1

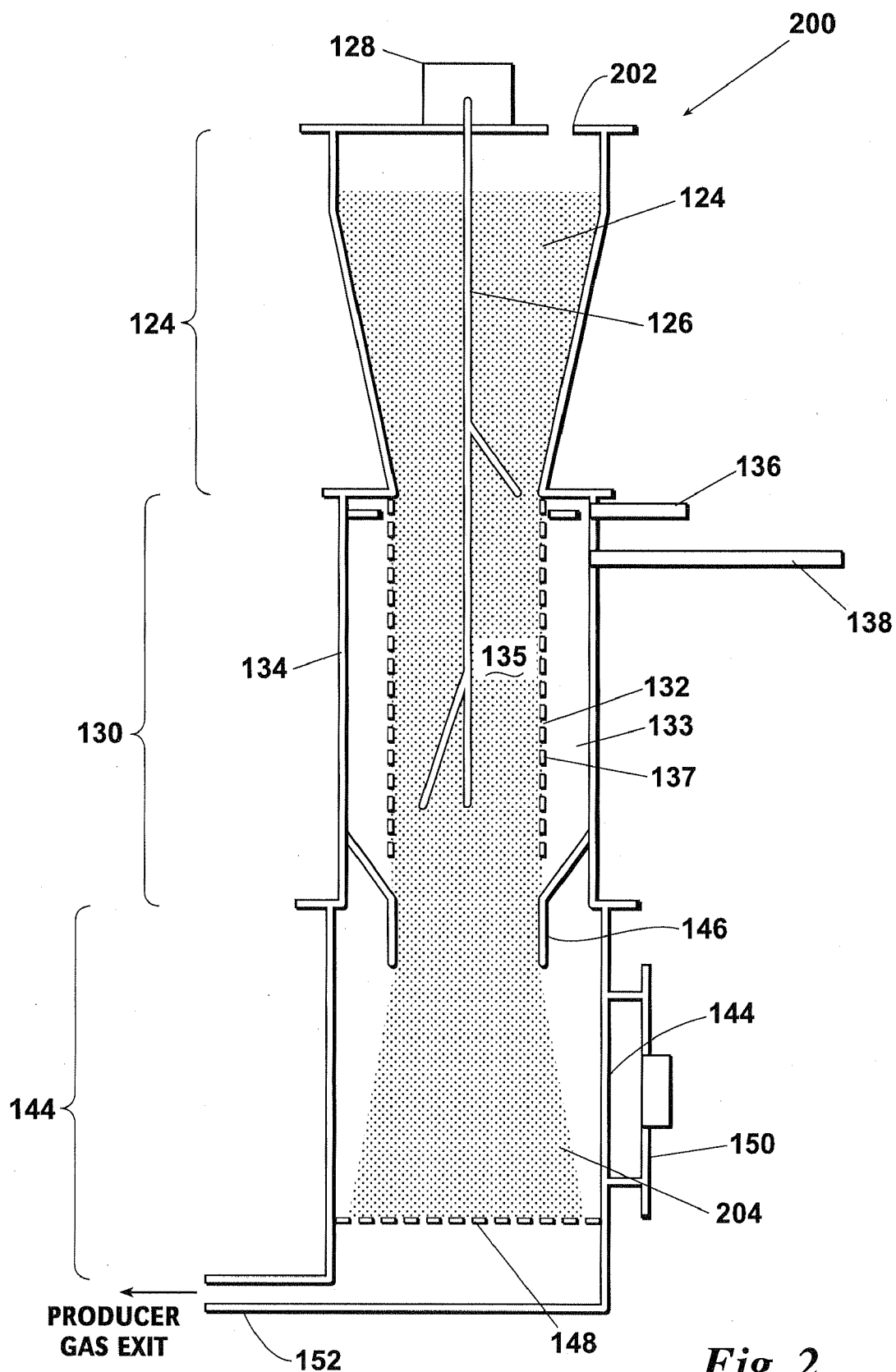


Fig. 2

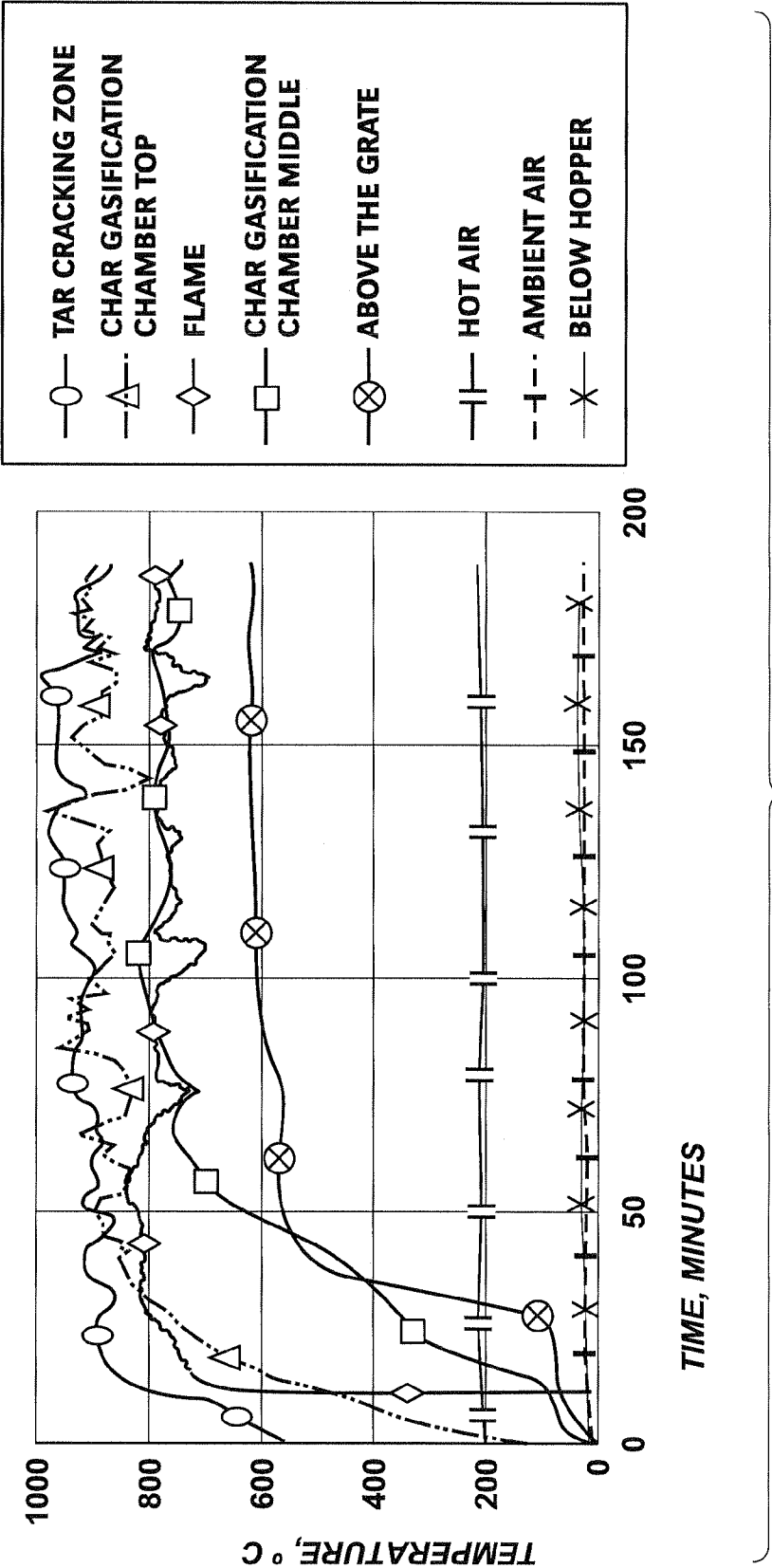
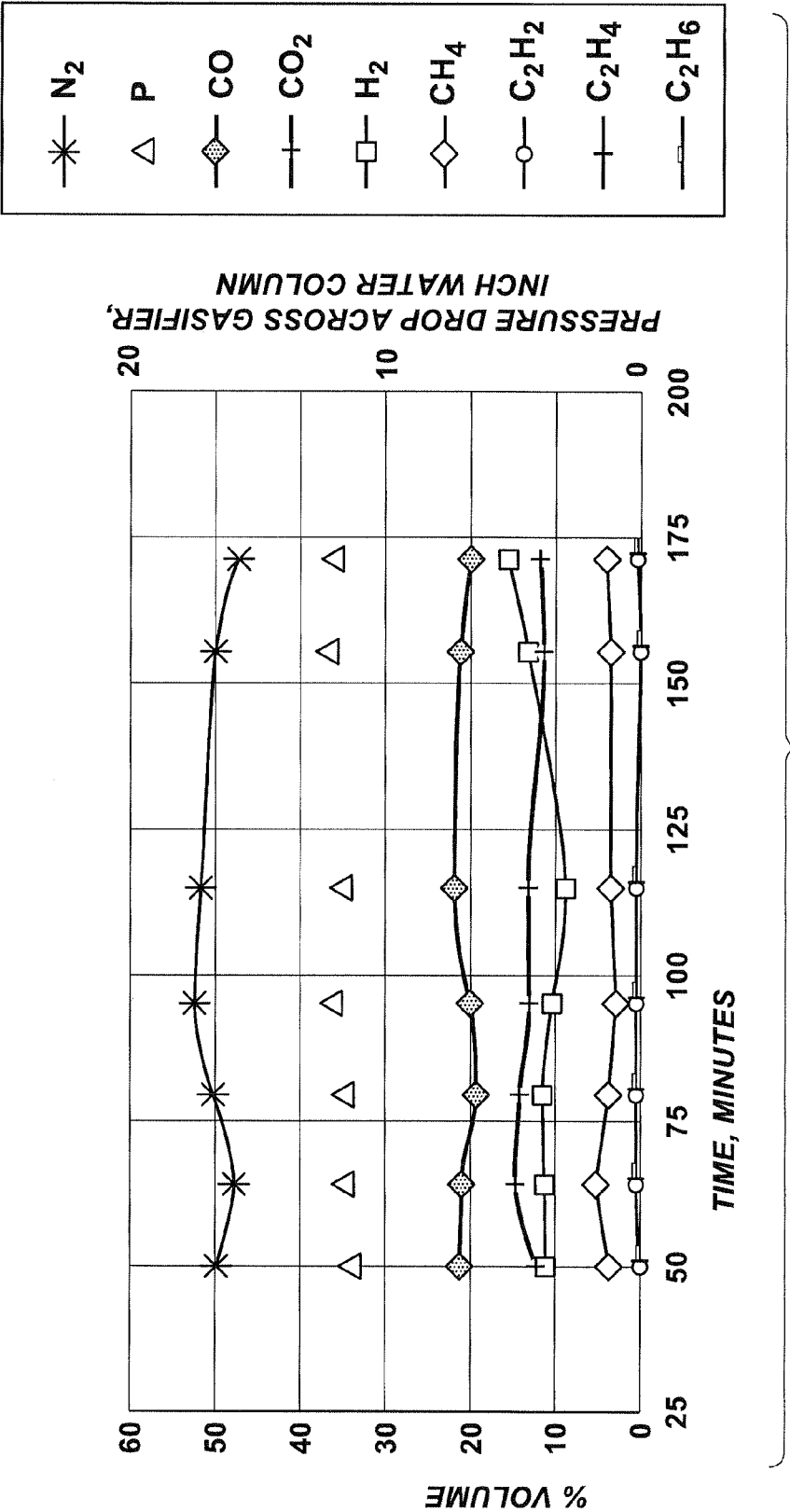
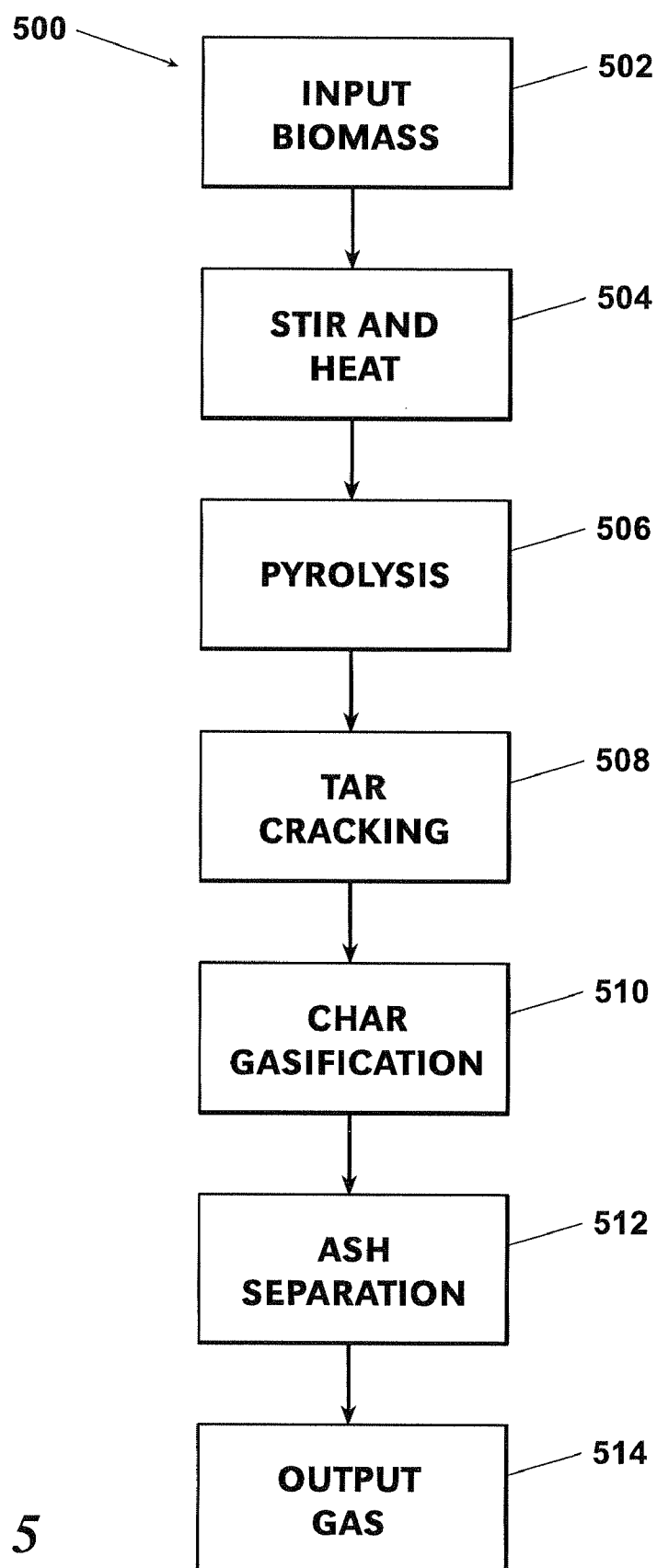


Fig. 3



*Fig. 5*

DOWNDRAFT GASIFIER WITH INTERNAL CYCLONIC COMBUSTION CHAMBER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 60/818,925 filed on Jul. 6, 2006, titled "Downdraft Gasifier with Internal Cyclonic Combustion Chamber," which is incorporated herein by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] This invention was made with government support under contracts 2000-52104-9662, 2003-34447-13162, and 2004-34447-14487 awarded by United States Department of Agriculture—Cooperative State Research, Education, and Extension Service. The government has certain rights in the invention.

FIELD OF THE INVENTION

[0003] This disclosure relates to gasification of biomass materials in general and, more specifically, to gasification by downdraft gasifiers.

BACKGROUND OF THE INVENTION

[0004] Biomass may be converted into useful gas products such as carbon monoxide (CO), carbon dioxide (CO₂), hydrogen (H₂), and others. There are multiple processes by which the raw biomass materials may be gasified. These include pyrolysis, tar cracking, and char gasification. Heating the biomass material under the proper circumstances such that the desired gases are released without being oxidized or otherwise consumed is one commonality among certain of the various gasification methods.

[0005] In order to obtain useful quantities of gases from raw biomass material the gasification process must be implemented in such a way as to operate in a steady state. The desirable gases, or production gases, should more or less be output a steady rate. Improper handling and processing of the biomass can result in a suboptimal amount of the raw biomass being gasified. Unacceptably high levels of undesirables can also be produced and taint the output gasses if the production process is not controlled.

SUMMARY OF THE INVENTION

[0006] The invention disclosed and claimed herein, in one aspect thereof, comprises a downdraft gasifier. The gasifier has a biomass feeding unit, a combustion chamber, and a separator unit. The biomass feeding unit accepts raw biomass materials and selectively feeds the materials into the combustion chamber. The combustion chamber provides means to induce pyrolysis, tar cracking, and char gasification of the raw biomass materials to produce gases and ash. The separator unit accepts the gases and ash from the combustion chamber and separates the gases from the ash.

[0007] The means to induce pyrolysis, tar cracking, and char gasification may comprise a biomass chamber, a tar cracking chamber, and a char gasification chamber. The tar cracking chamber further may comprise substantially cylindrical inner and outer walls. The inner wall may have a plurality of perforations therein. The perforations may be selectively closable.

[0008] The means to induce pyrolysis, tar cracking, and char gasification may further comprises a stirrer operable to stir biomass in the combustion chamber through at least the biomass chamber and a portion of the tar cracking section. A heat source may also be included. The separation unit may include a cyclonic separator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic diagram illustrating one embodiment of a gasification system according to aspects of the present disclosure.

[0010] FIG. 2 is a schematic diagram illustrating one embodiment of a gasification combustion chamber for use with the gasification system of FIG. 1.

[0011] FIG. 3 illustrates an exemplary temperature profile of a downdraft gasifier constructed according to aspects of the present disclosure.

[0012] FIG. 4 illustrates the pressure over time of various output gases from a gasifier constructed according to aspects of the present disclosure.

[0013] FIG. 5 is a flow diagram illustrating an embodiment of a gasification process according to the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Referring now to FIG. 1, a schematic diagram illustrating one embodiment of a gasification system according to aspects of the present disclosure is shown. The gasifier system 100 comprises three primary components: a biomass feeding unit 102; a combustion chamber 104; and a separator 106. These primary components may further comprise a number of subcomponents, which will be described in detail below. The system 100 is operable to accept biomass as an input product and provide useful gases as an output product. The producer gas may be a mixture of carbon monoxide (CO), carbon dioxide (CO₂), hydrogen (H₂), and possibly other gases. In one embodiment, the gasification system 100 operates to convert biomass material into the desired gases by means of pyrolysis and tar cracking. This result may be achieved by creating high temperatures within the combustion chamber 104. This causes the biomass material to break down into a number of materials, including ash and gases.

[0015] The biomass feeding unit 102 accepts the biomass intake product for processing by the system 100. Biomass materials suitable for use with the system 100 may include, but are not limited to, woodchips, sewage or sludge, and refuse from the processing of plant matter. The gasification system may also operate using input biomass from plants grown with the specific purpose of being fed into the gasification system 100.

[0016] The biomass feeding unit 102 comprises a hopper 108 and an agitator 110 with an agitator drive unit 112. The dimensions and specific shape of the hopper 108 may vary in accordance with the needs of the end user. In the present embodiment, the hopper 108 has a tapered cylindrical shape. The agitator 110 may be a bladed or impeller type agitator or another type of agitator suitable for the biomass used with the gasification system 100. It is also understood that stirrers, conveyors, or other implements could be used to ensure ready delivery of biomass material into the gasifier 100. In the

present embodiment where the agitator **110** is a rotational, the agitator drive unit **112** may be selected according to the duty cycle and torque requirements necessary to agitate the chosen biomass material. Some embodiments will provide a variable speed agitator. The agitator may be selectively operable such that it operates only when needed to insure proper feeding of the biomass.

[0017] In the present embodiment, a screw drive **114** serves to move biomass from the hopper **108** to an airlock **118**. In the present embodiment, a screw drive **114** is powered by a screw drive powering unit **116**. The screw drive powering unit **116** may be pneumatic, electrical, or powered by another source. The screw drive may be selectively operable and/or of variable speed so that feeding of the biomass may be properly controlled. In other embodiments, the screw drive **114** may be replaced with other conveyance means, such as conveyor belt, a slip stick movement device, or another suitable conveyance.

[0018] The air lock **118** serves to control the intake of biomass from the hopper **108** to the rest of the gasification system **100**. The air lock **118** also serves to prevent unwanted gases (e.g., air) from entering the combustion chamber **104**. Uncontrolled intake of ambient gasses may alter the desired chemical processes within the combustion chamber **104**. The airlock **118** may be electrically or mechanically powered. The airlock **118** or otherwise and may be remotely controllable, such as with an electronic relay, for example.

[0019] Beyond the air lock **118** is another screw drive **120**. The screw drive **120** is powered by another screw drive power unit **122**. These may be similar to the screw drive **114** and screw drive powering unit **116**. As before, in embodiments other than the one shown in FIG. 1, the screw drive **120**, as well as the screw drive powering unit **122**, could be replaced with other conveyance means. In some embodiments the airlock **118**, agitator **110**, and the screw drives **114**, **120** will operate in concert to ensure proper delivery of biomass to the combustion chamber **104**.

[0020] When the biomass material leaves the biomass feeding unit **102** it is fed into the combustion chamber **104**. The combustion chamber **104** provides a number of additional steps in the gasification process, which will be described in more detail below. A biomass section **124** may be provided near the top of the combustion chamber **104**. In one embodiment, the biomass section **124** serves to guide or direct the entering biomass material into the remainder of the combustion chamber **104**. The biomass section **124** may also be where the gasification process begins. High temperatures in the biomass section **124** may start an outgassing from the biomass material that will continue through the rest of the combustion chamber.

[0021] A stirrer **128** may be provided starting at the biomass section **124**. The stirrer may proceed further into the depths of combustion chamber **104**. The stirrer **126** may be made from a suitably heat resistant material able to withstand high temperatures necessary in the combustion chamber **104**. Blades or other agitating means may be provided on the stirrer **126**. The stirrer **126** is powered by a stirrer drive unit **128**. The stirrer drive unit may once again be electrical, pneumatic, mechanical or powered by another source. The biomass section **124** may be cylindrical, conical, or may have another shape. In one embodiment, the shape of the biomass section

124 serves to feed biomass material at the appropriate speed and volume down into a tar cracking section **130**.

[0022] The tar cracking section **130** may be generally cylindrical in shape and may provide an inner chamber **135**, defined by an inner cylindrical wall **132**. The inner wall **132** and an outer wall **134** may define an annular outer chamber **133**. It can be seen that the inner wall **132** may also feature perforations **134** that aid in the heating of the biomass material. As solid biomass in the inner chamber **135** is gasified, the gasses may escape the inner chamber **135** through the perforations **134** in the inner wall **132** into the annular chamber **133**.

[0023] It can be seen that in the embodiment shown the stirrer **126** proceeds at least part of the way through the inner chamber **135**. In this way, stirring or agitation is provided starting at the biomass section and proceeding through at least a portion of the tar cracking section **130**. This reduces and/or eliminates hot spots that would prevent efficient pyrolysis and tar cracking within the combustion chamber **104**.

[0024] In the present embodiment, the combustion chamber **104** is heated in part by the combustion of propane. The propane heating may only be necessary to start off the gasification process and may also serve to heat the biomass section **124**. In the present embodiment, propane enters through the fuel inlet **136** into the combustion chamber **104** where it may be ignited to produce heat. Although propane is used in the present example, it is understood that other fuel sources may be utilized, including but not limited to, natural gas, refined fuels, and other petroleum products.

[0025] It may be important to carefully control oxygen content within the combustion chamber **104**. An air inlet **138** is provided for oxygenating the environment of the combustion chamber **104**. An additional function of the air inlet **138** may be to provide heated air for furthering the gasification processes of the system **100**. Some embodiments will provide a heater **140** for preheating the air entering the combustion chamber **104**. The heater **140** may be gas or electrical powered or, in some embodiments, may be based off of the waste heat generated by another outside process. In some embodiments, the heater **140** will preheat the air to up to 300° C. or greater. A compressor **142** may also be provided for delivering the air into the combustion chamber **104** at the appropriate pressure. Pressurizing the ambient air will also heat the air to a certain degree, which may be useful in the gasification process. The compressor **142** can be electrical, pneumatic, or powered by another source. In the present embodiment, the heater **140** follows the compressor **142** resulting in higher efficiencies resultant from the heater **140** operating on compressed, and therefore hotter, air.

[0026] Various components of the system **100**, may be insulated for increased efficiency or productivity. For example, the air inlet **138** may be insulated. Similarly, all or a portion of the combustion chamber **104** may be insulated. In one embodiment, a ceramic wool blanket insulation (not shown) of about 25 mm thickness will be utilized. In other embodiment, different materials that are suitably heat resilient may be utilized. Additionally, the thickness of any insulation used may be varied based upon a number of factors including the desired reaction temperature, the ambient air temperature, efficiency concerns, and others.

[0027] Below the tar cracking section 130 is a char gasification section 144. In the present embodiment, the char gasification section 144 is separated from the tar cracking section by an annulus 146. This component may be optional depending upon the nature of the biomass material being utilized. In the present embodiment, the annulus 146 serves to guide the partially gasified biomass into the char gasification section 144.

[0028] The biomass material in the char gasification section 144 falls down onto a grating 148. The grating 148 serves as a separation step to separate the solid material from the gases created in the combustion chamber 104. It can be seen that the raw gases and ash are allowed to escape via a conduit 152 and travel to the separator 106. The remaining solid biomass material will remain trapped by the grating 148 where additional char gasification will occur. As the biomass further gasifies, the ash and gasses produced will pass through the grating and out the conduit 152.

[0029] It can be seen in FIG. 1 that the biomass section 124, the tar cracking section 130, and the char gasification section 144 may be arranged in a generally vertical fashion. The present embodiment provides the tar cracking section 130 in between the biomass section 124 and the char gasification section 130. In this configuration, gravity may serve to feed the biomass through the combustion chamber resulting in down draft type gasification process. The combustion and gasification in the combustion chamber 104 may serve to create swirls, vortices, and other cyclonic gas flows. These may be controlled and/or aided by the stirrer 126 and perforations 133 in the inner chamber wall 132 of the tar cracking section 130. This serves prevent cold spots in the combustion chamber 104, particularly as the size of the process is scaled up.

[0030] The configuration of the combustion chamber 104 also helps to ensure substantially complete transformation of the biomass material into gases and ash. The gasses will include producer gas and possibly waste gas. The ashes will contain substantially no inorganic material. Nevertheless, as a practical consideration, means may be provided for clearing any solid material captured on the grating 148 that is not consumed by char gasification. In one embodiment, this may be an access portal 150 located near the grating 148 on the char gasification section 144 of the combustion chamber 104. The access portal 150 may also allow for servicing, inspection, and/or replacement of the grating 148 and other components on the interior of the combustion chamber 104.

[0031] The separation section 106 provides a separator 154 for separating the production gas from the ash in the raw gas stream coming from the conduit 152. In one embodiment, the separator 154 is a cyclonic separator, but other separators may be utilized. The separator may be mechanical and may be electrically, pneumatically, or otherwise powered. The separated production gas is removed by the outlet 156. The present embodiment illustrates a burner 158 that consumes the production gas coming from the outlet 156. Thus, heat and other power may be provided for another process. However, it is understood that the production gas may be stored, utilized in a different manner, or further refined downstream of the gasification system 100. A storage chamber 160 is provided for catching and/or holding the ash from the separator 154. The ash may be useful in other processes and can therefore be

retained until needed. In the present embodiment, an access portal 162 is provided for periodically removing the ash from the storage chamber 160. It is understood, however, that other means may be utilized, such as conveyor belts or screw drives.

[0032] Referring now to FIG. 2, a schematic diagram illustrating one embodiment of a gasification combustion chamber for use with the gasification system of FIG. 1 is shown. FIG. 2 provides a more detailed view of another embodiment of the combustion chamber 104 for use with the gasification system shown in FIG. 1. It can be seen that the combustion chambers 200 and 104 are similar. Once again, a three-section embodiment is shown. The sections or chambers include the biomass section 124, the tar cracking section 130, and the char gasification section 144. A stirrer 126 is provided, driven by a stirrer drive unit 128. The fuel inlet 136 is shown, along with the air inlet 138. A grating 148 is provided near the bottom end of the char gasification section 144. Gases and ash escape through the gas conduit 152. It will be appreciated that the combustion chamber 200 may be utilized in the gasification system 100 of FIG. 1, directly replacing the combustion chamber 104 illustrated in FIG. 1.

[0033] As has been described, in one embodiment biomass is provided to the combustion chamber 200 through a biomass feeding unit. Biomass enters the combustion chamber 200 through an inlet 202. In FIG. 2, a biomass column 204 is illustrated to show one possible route for the biomass material through the combustion chamber 200. It can be seen that the stirrer 126 may serve to stir the biomass 204. As before, propane gas is introduced through the inlet 136. In the present embodiment, the propane is supplied near the top of the tar cracking section 130, and is used only for initial firing at start up of the process.

[0034] The tar cracking section 130 is once again formed by inner cylindrical walls 132 and an outer cylindrical wall 134. An inner chamber 135 is bounded by the inner wall 132 and an annular chamber 136 is formed between the inner wall 132 and outer wall 134. In the present embodiment, the entirety of the inner chamber 132 is provided with perforations 134. Various degrees of perforation of the inner chamber 132 may be utilized depending upon the raw biomass material being utilized. Some embodiments may provide for an adjustment of the degree of perforation using a sleeve or other means, for example. In the present embodiment, tar loaded pyrolysis gases are allowed to escape from the biomass 204 column through the perforations 134 where they are mixed with pre-heated air from the air inlet 138. The pressurized gas entering the tar cracking section 130 provides high temperature turbulence and swirling combustion flows, allowing tar cracking to occur.

[0035] The high temperature combustion products being produced in the tar cracking section 130 feed through the annulus 146 into the char gasification section 144. In the present embodiment, the char gasification section 144 provides for additional biomass decomposition by char gasification reactions. In some embodiments, temperatures of up to 1200 degrees Celsius are attained in the char gasification section 144.

[0036] It can thus be appreciated that biomass entering the combustion chamber 200 will undergo a continuous process whereby the gasification process begins as early as the bio-

mass section **124**. As the biomass is consumed, it is allowed to fall with the aid of the stirrer **126** into the tar cracking section where a majority of the pyrolysis of the process may occur. As the partially consumed biomass exits the tar cracking section **130**, it is allowed to fall downward into the gasification chamber **144** where it may land on the grating **148**. In some embodiments, the reaction of remaining biomass in the column **204** continues on the grating **148**. Gases and heat escaping downward through the combustion chamber **104** and out through the conduit **152** provide energy for the char gasification process on the grating **148**. Thus, a substantially complete reduction process will occur such that gases and essentially inorganic material, or ash, are allowed to flow freely through the conduit **152**.

[0037] Table 1 shows the characteristics of pine wood pellets that may be used as a feedstock (biomass) for operation of the gasification system of the present disclosure. Table 2 illustrates a summary of a number of gasification tests conducted utilizing a system constructed in accordance with FIG. 1. The table includes the temperatures reached by various locations within the system **100**, as well as the gases produced in percentage by volume thereof. It can be seen that in some of the tests, tar content and particulates were measured. Efficiency and mass balance percentages are also shown. The

mass balance percentages may not add up to exactly 100 due to measurement limitations and rounding errors in equipment.

TABLE 1

Wood pellet characteristics	
Proximate, (weight %, dry basis)	
Moisture content	7.5 ± 0.1
Volatile matter	82.2 ± 0.6
Fixed carbon	17.6
Ash	0.2 ± 0.03
Higher heating value, kcal/kg ^a	5075
Ultimate ^a (weight %, dry basis)	
Carbon C	52.13 ± 1.7
Hydrogen H	6.36 ± 0.3
Oxygen O	±41.23
Nitrogen N	0.07 ± 0.03
Sulphur S	0.01
Diameter (mm)	6.0
Length (mm)	10-35
Bulk density (kg/m ³)	660

^aBIOBIB. 1992. A database for biofuels. Available at: www.vt.tuwien.ac.at/Biobib/biobib.html. Accessed 8 May 2006.

TABLE 2

Summary of typical gasification operation				
	Test 1	Test 2	Test 3	Test 4
Equivalence ratio	0.18	0.21	0.23	0.17
Fuel feed rate, kg/h	17.0	14.8	13.0	18.1
Input air temperature, C.	216 ± 4	205 ± 3	216 ± 17	219 ± 4
Tar cracking zone (TCZ) temperature, (Ave.), C.	854 ± 43	896 ± 38	866 ± 48	800 ± 48
TCZ temp. (Max.), C.	966	1001.7	1002	975
Char gasification (CG) chamber top, Ave., C.	706 ± 38	770 ± 22	556 ± 208	708 ± 50
CG chamber top, (Max), C.	793	819	786	844
CG chamber mid, (Ave.) C.	742 ± 27	790 ± 26	607 ± 181	731 ± 25
CG chamber mid, (Max.) C.	789	827.7	768	769
Gas temperature after cyclone separator, C.	352 ± 4	383	350 ± 7	356 ± 26
Flame temp. (Ave.), C.	770 ± 25	780 ± 31	777 ± 30	777 ± 24
Flame temp. (Max.), C.	813	843.4	829	829
Pressure drop across gasifier, Inch of water	11.0 ± 0.6	12.0 ± 0.4	10.4 ± 0.4	10.4 ± 0.3
Gas composition, % vol.				
CO	22.7 ± 0.9	21 ± 0.9	21.2 ± 2.1	21.6 ± 1.3
H ₂	10.9 ± 1.6	11.9 ± 2.3	11.6 ± 1.7	12.4 ± 2.2
CH ₄	3.4 ± 0.7	3 ± 0.7	3.1 ± 0.8	3.6 ± 1.1
CO ₂	13.4 ± 0.9	13.3 ± 1.1	13.4 ± 0.6	13.1 ± 1.0
N ₂	48.8 ± 1.7	50.3 ± 1.8	50 ± 2.1	48.3 ± 3.5
C ₂ H ₂	ND*	0.1 ± 0.2	ND*	0.2 ± 0.4
C ₂ H ₄	0.5 ± 0.1	0.4 ± 0.2	0.5 ± 0.1	0.7 ± 0.3
C ₂ H ₆	0.2 ± 0.3	0.1 ± 0.1	0.1 ± 0.3	0.1 ± 0.1
LHV gas (kcal/Nm ³)	1369	1277	1293	1423
Dry gas yield (Nm ³ /kg)	1.69	1.88	2.16	1.60
Tar content, g/Nm ³	Not measured	7.5	5	12
Particulates, g/Nm ³	Not measured	0.45	0.4	0.4
Hot gas efficiency, %	63.2	71.6	80.7	60.5
Cold gas efficiency, %	56.3	63	71.9	54
Mass balance, %	98	101	105	94

*Not detected.

[0038] Referring now to FIG. 3, an illustration of an exemplary temperature profile of a downdraft gasifier constructed according to aspects of the present disclosure is shown. The measurements of FIG. 3 were taken with a gasifier built according to the present disclosure. Referring also to FIG. 4, the pressure over time of various output gases from the gasifier is shown. With reference to FIGS. 3 and 4, it can be seen that within 60 minutes from system start time, the gasifier system operation was stabilized. FIG. 4 reveals that throughout the test period of three hours, concentration levels of all gases were stable. The present embodiment produces gases with a heating value in the range of 1277 to 1423 kilocalories per cubic meter. Volumetric CO, H₂, and CO₂ concentrations are in the range of 21-23%, 11-13%, and 13-13.5% percent, respectively. Tar cracking zone temperatures were maintained close to 1000 degrees Celsius. Hot gas efficiency ranged from 63 to 81 percent. Average producer gas flame temperatures were approximately 780 degrees Celsius. Tar and particulate contents in the raw producer gas were in the range of 5 to 12 grams per cubic meter and 0.4 to 0.45 grams per meter cubed, respectively. It can be seen that the results corresponding to the performance of a gasifier constructed according to the present disclosure are comparable to the performance of a conventional throat type downdraft gasifier. This relationship is illustrated for reference in Table 3.

TABLE 3

Gasifier performance comparison with other published data on conventional downdraft gasification systems					
Feedstock	Air-to-fuel ratio,	Tar cracking Temp, ° C.	% Volume		
	Nm ³ /kg		CO	H ₂	Tar, g/Nm ³
Hazelnut shells	1.46	1050	21	13.1	3.0
Sewage sludge	2.3	1077	10.6	10.9	6.26
Wood chips	Equivalence ratio of 0.38	1000	24	14	No data
Pine wood pellets (this study)	Equivalence ratio of 0.23	1000	21	12	5.0

[0039] Referring now to FIG. 5, a flow diagram illustrating one method of a gasification process according to the present disclosure is shown. FIG. 5 illustrates a simplified version of one gasification method that may be accomplished by the systems of the present disclosure. At step 502, biomass is input to the system. At step 504, the biomass will be stirred and heated. Stirring could be done in a biomass chamber, for example. Heating could be accomplished by a propane flame and/or heated air, or by other means. Pyrolysis begins at step 506. However, it is understood that stirring and heating may continue to even as pyrolysis occurs.

[0040] At step 508 tar cracking occurs. As before, it is understood that pyrolysis may still be occurring when tar cracking has begun. Stirring and heating of the biomass as shown at step 504 may also still be occurring. With reference back now to FIG. 1, it can be seen in the combustion chamber 104 of the system 100 that stirring and heating at 504, pyrolysis at step 506, and tar cracking at step 508 may be simultaneously and/or continuously occurring.

[0041] Char gasification begins at step 510. Although char gasification is illustrated as the last of the actual gasification

steps, referring again to FIG. 1, it will be clear that the char gasification at step 510 can occur simultaneously with stirring and heating at step 504, pyrolysis at step 506, and/or tar cracking at step 508.

[0042] Following the reduction of substantially all of the biomass through pyrolysis, tar cracking, and/or char gasification, the raw gases will be separated from the ash contained therein at step 512. Following removal of the ash at step 512, the gas may be output at step 514. As previously described, the output gas may have a number of uses, such as immediate consumption, storage, and/or further refining.

[0043] Thus, the present invention is well adapted to carry out the objectives and attain the ends and advantages mentioned above as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, numerous changes and modifications will be apparent to those of ordinary skill in the art. Such changes and modifications are encompassed within the spirit of this invention as defined by the claims.

What is claimed is:

1. A downdraft gasifier comprising:

- a biomass feeding unit;
- a combustion chamber; and
- a separator unit;

wherein the biomass feeding unit accepts raw biomass materials and selectively feeds the materials into the combustion chamber, the combustion chamber providing means to induce pyrolysis, tar cracking, and char gasification of the raw biomass materials to produce gases and ash, the separator unit accepting the gases and ash from the combustion chamber and separating the gases from the ash.

2. The device of claim 1, wherein the means to induce pyrolysis, tar cracking, and char gasification comprises a biomass chamber, a tar cracking chamber, and a char gasification chamber.

3. The device of claim 2, wherein the tar cracking chamber further comprises substantially cylindrical inner and outer walls.

4. The device of claim 3, wherein the inner wall defines a plurality of perforations on at least a portion thereof.

5. The device of claim 4, further comprising means for selectively closing the perforations.

6. The device of claim 2, wherein the means to induce pyrolysis, tar cracking, and char gasification further comprises a stirrer operable to stir biomass in the combustion chamber through at least the biomass chamber and a portion of the tar cracking section.

7. The device of claim 2, wherein the means to induce pyrolysis, tar cracking, and char gasification further comprises a heat source.

8. The device of claim 1, wherein the separator unit comprises a cyclonic separator.

9. A cyclonic combustion chamber comprising:

- a biomass chamber with a stirrer that accepts biomass material and stirs it;
- a tar cracking chamber feeding from the biomass chamber, the tar cracking chamber gasifying the biomass material by pyrolysis and tar cracking of the biomass material through application of heat; and
- a char gasification chamber having a grating for trapping remaining biomass material from the tar cracking chamber and holding the same during a period of char gasification.

10. The cyclonic combustion chamber of claim **9**, wherein the biomass chamber is above the tar cracking chamber, which is above the char gasification chamber, such that the biomass material is gravity fed through the combustion chamber.

11. The cyclonic combustion chamber of claim **9** further comprising an outlet conduit for removing the gasified biomass material and ash from the combustion chamber.

12. The cyclonic combustion chamber of claim **9**, wherein the tar cracking chamber further comprises inner and outer walls, the inner wall defining a plurality of perforations therein.

13. The cyclonic combustion chamber of claim **12**, wherein the plurality of perforations are selectively closable.

14. A method of producing gases from biomass, the method comprising:

- heating biomass materials to induce pyrolysis;
- feeding the biomass materials into a tar cracking chamber to induce tar cracking; and
- feeding the biomass materials into a char gasification chamber for char gasification.

15. The method of claim **14**, wherein heating further comprises heating with fuel combustion.

16. The method of claim **14**, wherein heating further comprises heating with heated air.

17. The method of claim **14**, further comprising:

- collecting gases and ash resultant from the pyrolysis, tar cracking, and char gasification through a single conduit; and
- separating the collected gases and ash.

18. The method of claim **14**, further comprising stirring the biomass through at least a portion of the pyrolysis and the tar cracking.

19. The method of claim **14**, wherein feeding the biomass materials into a tar cracking chamber and feeding the biomass materials into a char gasification chamber are accomplished via a gravity feed.

20. The method of claim **14**, wherein feeding the biomass materials into a tar cracking chamber to induce tar cracking further comprises feeding the biomass materials into a double-walled tar cracking chamber, the inner and outer wall being substantially cylindrical, and the inner wall defining a plurality of perforations sized to allow gasses to flow therethrough.

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