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(54) **INDEPENDENT VECTOR CONTROL SYSTEM FOR GASIFICATION FURNACE**

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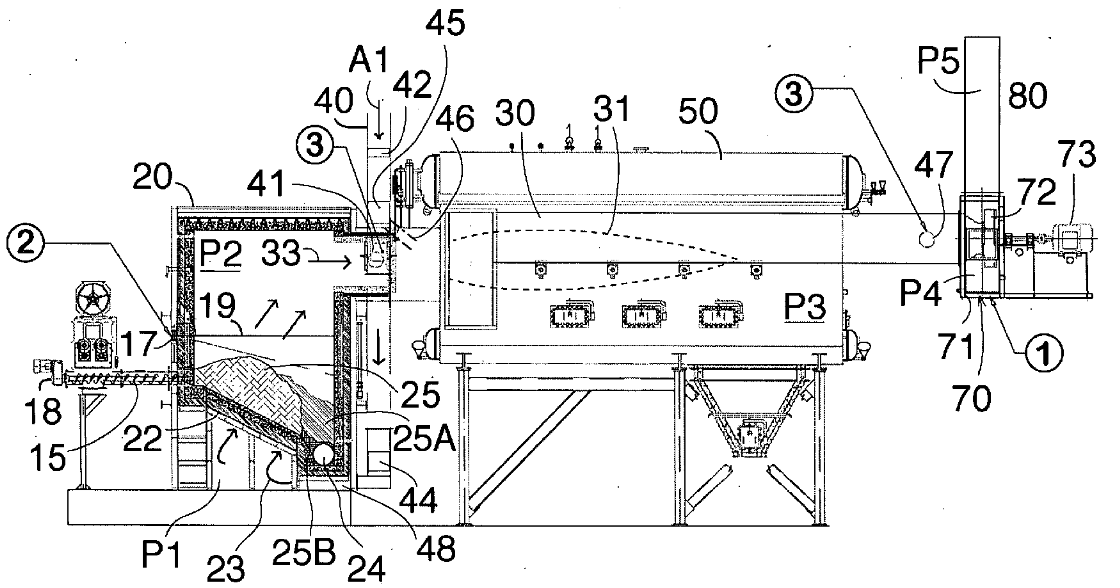
(57) **ABSTRACT**

A control sequencing system for a biomass fuel gasification furnace utilizes control vector separation and isolation. The three vector system provides clean operation and fuel efficiency. A wide variety of solid fuel may be used of various fuel values, moisture content, and fuel particle size. The independent control vectors are separated into fan speed, fuel pile level maintenance, and oxygen content maintenance.



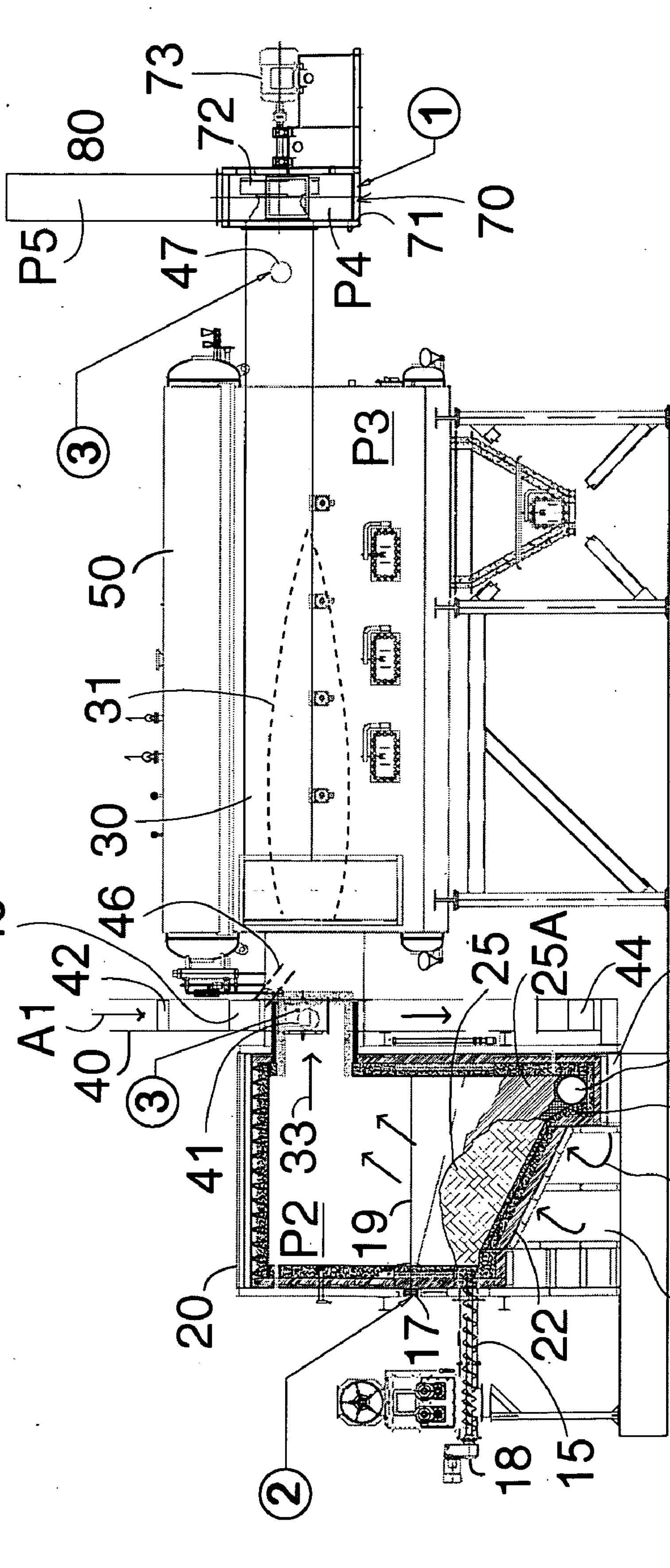

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FIG. 1

INDEPENDENT VECTOR CONTROL SYSTEM FOR GASIFICATION FURNACE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable.

THE NAMES OF THE PARTIES TO A JOINT RESEARCH OR DEVELOPMENT

[0003] Not Applicable.

BACKGROUND OF THE INVENTION

[0004] 1. Field of the Invention

[0005] The present invention relates to biomass fuel gasification chambers and particularly to a control sequencing system for a biomass gasification furnace which utilizes control vector separation and isolation for cleaner operation and more fuel efficiency and which allows the use of widely varying fuel value and fuel particle size; the control vectors being separated into three independent controls: fan speed, fuel pile level maintenance, and oxygen content maintenance.

[0006] 2. Description of Related Art Including Information Disclosed Under 37 CFR 1.97 and 1.98

[0007] Most biomass gasification systems have historically had electronic and combustion control problems because of the complexity and variability of the inputs. Because of the complexity and variability of these inputs, it is very difficult to reach a "perfect" or steady state control status. Most systems have inputs like varying boiler loads, fan speed, damper control, metering rate, feed speed, fuel value (moisture, minerals, and particle size), ash removal, etc. Because of these variables, the systems are rarely in "perfect" combustion status, but are constantly chasing their tail in order to try to satisfy all of the inputs. The result is a poorer quality of combustion, resulting in poor fuel utilization, increased ash, (carbon) waste, poor air quality, poor combustion of the volatile organics, excess ash, smoking, etc.

[0008] U.S. Patent Application #20040261670, published Dec. 30, 2004 by Dueck, claims a biomass gasification system for efficiently extracting heat energy from biomass material. The biomass gasification system includes a primary combustion chamber, a rotating grate within the primary combustion chamber for supporting the biomass during gasification, a feeder unit in communication with the primary combustion chamber for delivering biomass, a secondary combustion chamber fluidly connected to the primary combustion chamber, an oxygen mixer positioned between the primary combustion chamber and the secondary combustion chamber, a heat exchanger and an exhaust stack. The invention is provided with a control unit which is in communication with the oxygen mixer, the disintegration unit the feeder unit, the air distribution system, the exhaust blower, the drive motor and the fuel conveyor. The control unit may be in communication with these devices via direct electrical connection, radio signal or other communication means. The control unit may be comprised of a computer or other electronic device capable of storing various types of data including input data, program data and the like.

[0009] U.S. Patent Application #20010027737, published Oct. 11, 2001 by Abrams, describes a gasifier energy conversion system which comprises a solid fuel fed combustor system having a first chamber portion with an inlet feed for feeding a metered amount of a solid fuel thereto, a first burner stage having a first traveling conveyor firebelt, a metered amount of air introduced in progressively increasing proportions along the length of the first traveling conveyor. A second burner stage having a second traveling conveyor firebelt with air introduced in a progressively decreasing amount along the length of said second traveling conveyor firebelt and a controller for controlling air introduced to the system. The chamber has a sloped common roof section common to the burner stages and is made of radiative energy reflective fire brick and angled to reflect radiative energy generated from fuel traveling on the traveling conveyor firebelts and directing the radiative energy on fuel traveling on the first firebelt. The air introduced is controlled in amounts so as to automatically minimize excess air to the firebelt conveyors to minimize the quantity of carbon monoxide and nitrogen oxides and other pollutants. A control system is provided which is the determining factor for the gasification system to operate properly and to be in compliance with the regulatory requirements for air discharge. It includes Programmable Logic Controllers (PLC's) and variable speed drives that operate the various motors, fans and drives that operate the gasifier system.

[0010] U.S. Patent Application #20050229824, published Oct. 20, 2005 by Lefcort, discloses a two-stage wet waste gasifier and burner comprising a first-stage combustion chamber which has a symmetrical grate arrangement. The grate comprises spaced individual upright air supply tubes with flat horizontal upper surfaces swept by ash-removal plates. The height and width of the air supply tubes are selected to provide an upper surface profile approximating the natural angle of repose of the waste. Twin waste feed distribution augers span the chamber and rotate in mating troughs. The axis of rotation of each auger is sloped so that the discharge end of the auger is higher than the feed inlet end, and the trough sidewalls are inclined downwardly from the inlet end to the discharge end; these attributes promote even discharge of waste across the span of the chamber. Vertical walls of the air supply tubes are provided with air ports for supplying combustion air; the vertical orientation of the apertures and a degree of shielding of the upper surfaces of the air supply tubes inhibit clogging of the air ports. Drivers for the ash-removal plates comprise pendular arms each pivoting about an upper pivot point lying substantially in the vertical plane of symmetry, each arm being pivotally connected directly or indirectly to the ash removers. A burner of the foregoing type may be combined with a dryer for drying a portion of the waste and with a mixer that mixes dried waste with raw wet waste and feeds the mixed waste to the burner. The mixed waste can be efficiently burned yet can be efficiently conveyed. Such combination is particularly suitable for combustion of sewage sludge. The invention is provided with a control unit which regulates the pile height, fuel feed augers, thermal sensors, and ash removal.

[0011] U.S. Pat. No. 5,279,234, issued Jan. 18, 1994 to Bender, is for a controlled clean-emission biomass gasification heating system/method. A biomass fuel gasification chamber, blast tube, and heat exchange chamber are interconnected horizontally and subjected to negative drawing pressure by a large variable speed chimney fan. An auger with an air lock feeds biomass fuel automatically into the gasification chamber. Fuel is moved across the gasification chamber on a partially serrated sloping grate. Three stages of fuel activity are created: anaerobic heating for pyrolysis, combustion, and incandescent charcoal oxidation for gasification. A variable speed fan, variable flue, and directional air duct and baffles control the stages with underfire air. A programmed auger in an airtight chamber removes ash automatically. In large systems a hydraulic moving wedge floor assists the fuel feeding auger and a moving sloping grate moves the fuel. A fan and long preheating duct with baffles and fins inside the gasification chamber preheat and direct air into a blast tube leading from the gasification chamber. Openings from the preheating tube angled both longitudinally and transversely into the blast tube create turbulence in the blast tube directed away from the gasification chamber. Preheated directed air flow and the negative pressure of the chimney fan draw gases from the gasification chamber into the blast tube, crack the gases, and shoot a fire blast into the heat exchange chamber. The fire blast heats an external system. Particulates are removed producing a clean-emission exhaust gas. Temperature and air quality sensors in the chimney provide feedback signals to various system controls to maintain optimum operating conditions.

[0012] U.S. Pat. No. 6,981,455, issued Jan. 3, 2006 to Lefcort, provides a two-stage wet waste gasifier and burner comprising a first-stage combustion chamber which has a symmetrical grate arrangement. The grate comprises spaced individual upright air supply tubes with flat horizontal upper surfaces swept by ash-removal plates. The height and width of the air supply tubes are selected to provide an upper surface profile approximating the natural angle of repose of the waste. Twin waste feed distribution augers span the chamber and rotate in mating troughs. The axis of rotation of each auger is sloped so that the discharge end of the auger is higher than the feed inlet end, and the trough sidewalls are inclined downwardly from the inlet end to the discharge end; these attributes promote even discharge of waste across the span of the chamber. Vertical walls of the air supply tubes are provided with air ports for supplying combustion air; the vertical orientation of the apertures and a degree of shielding of the upper surfaces of the air supply tubes inhibit clogging of the air ports. Drivers for the ash-removal plates comprise pendular arms each pivoting about an upper pivot point lying substantially in the vertical plane of symmetry, each arm being pivotally connected directly or indirectly to the ash removers. A burner of the foregoing type may be combined with a dryer for drying a portion of the waste and with a mixer that mixes dried waste with raw wet waste and feeds the mixed waste to the burner. The mixed waste can be efficiently burned yet can be efficiently conveyed. Such combination is particularly suitable for combustion of sewage sludge. The invention is provided with a control unit which regulates the pile height, fuel feed augers, thermal sensors, and ash removal.

[0013] U.S. Pat. No. 6,647,903, issued Nov. 18, 2003 to Ellis, shows an apparatus and method for generating fuel gas and optionally, activated carbon gasification from biomass fuel. A control system receives input signals from and provides output signals to the fuel supply, the gasifier, the cooling/cleaning unit, the engine, and the flare unit.

[0014] U.S. Pat. No. 6,758,150, issued Jul. 6, 2004 to Ballantine, claims a system and method for thermally reducing solid and liquid waste and for recovering waste heat. A system and method are set for pyrolysis of waste feed material including a first retort segment disposed through a combustion chamber and a second retort segment disposed outside of the combustion chamber. The combustion chamber supplies the heat for pyrolysis to the material conveyed through the first retort segment, which pyrolysis is completed as it is conveyed through the second retort segment. A thermal oxidizer oxidizes off gases and a stack unit provides a draft to move the gases from pyrolysis from the retort segments and through the thermal oxidizer. A controller is provided which accepts the data from various sensors to monitor operations, as well as to determine if any problems in the system have arisen, e.g. blocked inlet or discharge, screw motor failure or the like. Other sensors and monitors may be provided such as oxygen sensors and/or pressure sensors for the first and second retort segments to sense an undesirable combustion or explosive situation wherein the controller may activate a nitrogen flooding system to flood the retort segments, thermal oxidizer and/or combustion chamber. Under the control of the controller the system may operate on an automated bases based upon a pre-programmed sequence and based upon the empirically or experimentally determined parameters for the feed material.

[0015] U.S. Pat. No. 6,615,748, issued Sep. 9, 2003 to Sunter, describes a method and portable apparatus for the conversion of cellulose and other biomass waste materials through a pyrolysis and partial combustion sequence in a downdraft gasifier to produce a gas which can be immediately utilized to fuel an internal combustion engine in a generator set (genset). More specifically, the heat from the combustion of part of the cellulosic or other waste input is used to pyrolyze the remainder of the input to produce a mixture of permanent fuel gases. Particulates are removed (water scrubbers, filters) from the gas mixture which can then be used directly as a major part of the fuel to operate the internal combustion engine in the genset. All movement into, through, and out of the gasifier and purification train is controlled by the vacuum associated with the intake of the internal combustion engine, thereby ensuring a steady production of electricity. A programmable logic computer (PLC) may be used to control the plant functions.

[0016] U.S. Pat. No. 6,269,755, issued Aug. 7, 2001 to Boswell, discloses various burner configurations for combustion of a particulate fuel such as sawdust, and many types of varying moisture content biomass fuels such as poultry litter. The burners exhibit a high turndown ratio. the burners include a housing defining an upright combustion chamber lined with refractory material and generally circular cross section, a main combustion region within an upper extent the combustion chamber, an initial combustion zone at a lower end of the combustion chamber of reduced-size cross-section compared to the combustion chamber and a transition region increasing in cross-section from the initial combustion zone to the main combustion region. A principal fuel (e.g., sawdust) is supplied with combustion air to the initial combustion region, and an auxiliary ignition fuel supplies heat to the initial combustion region for igniting the principal fuel. Multiple sets of tuyeres are provided for controllably introducing combustion air tangentially regions of the combustion chamber for contributing to cyclonic combustion flow in such a manner as to increase diameter of combustion upwardly within the combustion chamber. A counterflow arrangement, e.g., counterflow tuyere, disrupts cyclonic flow near a ceiling of the combustion chamber, through which a choke or exit provide escape from the combustion chamber of exhaust gases resulting from combustion. A programmable logic controller

(PLC) automatically controls the burner and smoke-combustor. The PLC accepts temperature inputs from a heat demand source. The burner increases or decreases the amount of beat supplied to the heat demand source based on parameters programmed into the PLC. These parameters consist of temperatures that the heat source should be maintained at during any time in the process cycle, of heat demand source. To maintain the correct temperature, the PLC sends electronic output signals to frequency changers controlling the speed of motors on air blowers and motors on fuel feed motors. The air blowers supply all of the air to the burner as described in the previous paragraphs. The PLC also sends electronic signals to valves located in the air supply lines to tuyeres to further regulate the airflow to the burner. The PLC receives temperature signals from the burner. It uses the temperature signals to monitor the internal condition of the burner and to make corrections if necessary. Electronic input signals are also received from the gas or oil fired burner, which tell the PLC if the burner is operating properly. Other input signals can be transmitted to the PLC signifying the status of motors, blowers, fuel handing equipment, etc., as conditions may dictate. Output signals can be added to operate other peripheral equipment, turn on alarms, provide current data, stored data, etc. as may be required. The PLC also regulates the speed of the ID fan when the latter is part of the system for thereby controlling the extent of partial pressure which results in air being drawn into the tuyeres.

[0017] U.S. Pat. No. 6,485,296, issued Nov. 26, 2002 to Bender, indicates a variable moisture biomass gasification heating system and method. A sloping fuel grate allows primary air to flow up into a thick biomass fuel bed in a gasifier which produces combustible gases. Fuel feed screws keep the fuel bed at a nearly constant height in response to a level indicator. A burner above the fuel bed admits swirling secondary air and combustible gases, burning the gases to produce a flame to heat a boiler or other heat applying device. A donut shaped collar in the burner prevents gases from leaking back into the burner. A programmable logic controller maintains the system at a desired optimum level of operation based on signals from oxygen, moisture, pressure, temperature and fuel bed height sensors. The controller sends signals to controls for primary air valves and dampers, fuel feeder, and an induced draft fan and optional combined primary and secondary air fan controlling the pressure and flow of air and gases for the system.

[0018] U.S. Pat. No. 7,007,616, issued Mar. 7, 2006 to Abrams, puts forth an oxygen-based biomass solid fuel combustion method and system which has an air separator for separating oxygen from air providing a supply of oxygen for feeding oxygen to a solid fuel combustion chamber. An airlock feeds a metered amount of solid fuel to the solid fuel combustion chamber. A burner stage having a firetube for collecting fuel gases from the solid fuel combustion chamber combusts the collected fuel gases with further oxygen from the separator and heats a boiler to generate steam. A heat utilization device (e.g. an electrical generator) may be connected to the steam boiler. Nitrogen-free diluent gases (e.g. argon and carbon dioxide) are used to control combustion process temperatures. The usable heat energy and useful byproducts are extracted from the different stages of the process. A control system is provided which is the determining factor for the gasification system to operate properly and to be in compliance with the regulatory requirements for air discharge. It includes Programmable Logic Controllers (PLC's) and variable speed drives that operate the various motors, fans and drives that operate the gasifier system.

[0019] U.S. Pat. No. 6,959,654, issued Nov. 1, 2005 to Abrams, concerns a gasifier system and method comprising a solid fuel fed combustor method having a first chamber portion with an inlet feeding a metered amount of a solid fuel to a first burner stage having a first traveling conveyor firebelt. A metered amount of air is introduced in progressively increasing proportions along the length thereof to cause endothermic reduction of the solid fuel. The first stage feeds a second burner stage having a second traveling conveyor firebelt. Air is introduced in a progressively decreasing amount along the length of the second traveling conveyor firebelt to induce exothermic combustion and decomposition of fuel. The amount of air introduced and speed of the conveyors are controlled to minimize the quantity of carbon monoxide and nitrogen oxides and other pollutants. Radiative energy generated from fuel traveling on the traveling conveyor firebelts is reflected on fuel traveling on the first firebelt. The computer control system is the determining factor for the gasification system to operate properly and to be in compliance with the regulatory requirements for air discharge. It includes Programmable Logic Controllers (PLC'S) and variable speed drives that operate the various motors, fans and drives that operate the gasifier system. The PLC'S are in turn controlled by signals from a computer that is programmed to recognize all the variables listed plus other minor items and to react properly from the data base. The program is designed to make adjustments for different types of fuels (with different BTU content) without changing equipment in the gasifier system.

[0020] U.S. Pat. No. 6,532,879, issued Mar. 18, 2003 to Abrams, illustrates a solid fuel fed combustor or gasifier system having a first chamber portion with an inlet feed for feeding a metered amount of a solid fuel thereto, a first burner stage having a first traveling conveyor firebelt, a metered amount of air introduced in progressively increasing proportions along the length of the first traveling conveyor. A second burner stage having a second traveling conveyor firebelt with air introduced in a progressively decreasing amount along the length of said second traveling conveyor firebelt and a controller for controlling air introduced to the system. The chamber has a sloped common roof section common to the burner stages and is made of radiative energy reflective fire brick and angled to reflect radiative energy generated from fuel traveling on the traveling conveyor firebelts and directing the radiative energy on fuel traveling on the first firebelt. The computer control system is the determining factor for the gasification system to operate properly and to be in compliance with the regulatory requirements for air discharge. It includes Programmable Logic Controllers (PLC'S) and variable speed drives that operate the various motors, fans and drives that operate the gasifier system. The PLC'S are in turn controlled by signals from a computer that is programmed to recognize all the variables listed plus other minor items and to react properly from the data base. The program is designed to make adjustments for different types of fuels (with different BTU content) without changing equipment in the gasifier system.

[0021] What is needed is advanced independent control sequencing for a biomass gasification furnace which is implemented by separating and isolating the existing control vectors, to include three simple, separate, essentially unrelated control vectors: fan speed, fuel pile level maintenance, and oxygen content maintenance.

BRIEF SUMMARY OF THE INVENTION

[0022] An object of the present invention is to provide a control sequencing system for a biomass gasification furnace which utilizes control vector separation and isolation for cleaner operation and more fuel efficiency and which allows the use of widely varying fuel value and fuel particle size; the control vectors are separated into fan speed, fuel pile level maintenance, and oxygen content maintenance.

[0023] In brief, the present invention provides a control sequencing system for a biomass fuel gasification furnace which utilizes control vector separation and isolation for cleaner operation and more fuel efficiency and which allows the use of widely varying fuel value and fuel particle size. The independent control vectors are separated into fan speed, fuel pile level maintenance, and oxygen content maintenance.

The controls are separated into:

[0024] 1. Fan Speed: The boiler load requirements control the induced draft fan speed with variable speed drives. As the boiler demand goes up, so does the fan speed. This draws more air through the fuel and creates more pyrolitic gasses to oxidize in the boiler.

[0025] 2. Fuel pile level: The system uses either a mechanical or electronic, internal or external fuel pile leveling device, depending on the model. The fuel pile level is maintained to within a few centimeters of the desired level. As fuel is used up, the feed rate goes up, and as the pile reaches the desired level the feed rate slows down. The system a wide variety of fuel values of the material, including a variety of moisture contents, mineral contents, and particle sizes.

[0026] 3. Oxygen trim: A stack sniffing device is constantly monitoring the stack gas for oxygen content from the first start up to the final burn out. The monitor adjusts the Primary/Secondary Air Damper to optimize the damper setting regardless of the load, nature of the fuel, or firing rate, thereby optimizing the combustion of the pyrolitic gas in the device.

[0027] The separation and isolation of these control vectors allows a much cleaner, more fuel efficient, less polluting operation of the equipment. It also allows the use of a widely varying fuel value and particle size fuel material. It also allows more efficient carbon utilization both in the gasifier and in the boiler.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0028] These and other details of my invention will be described in connection with the accompanying drawings, which are furnished only by way of illustration and not in limitation of the invention, and in which drawings:

[0029] FIG. **1** is a diagrammatic view of the three independent control vector system of the present invention for a biomass gasification furnace.

DETAILED DESCRIPTION OF THE INVENTION

[0030] In FIG. **1**, a three independent vector control sequencing system for a biomass gasification furnace shows the three totally separate controls including a fan speed control **1** indicated by the number one in a circle, a fuel level control **2** indicated by the number two in a circle, and the oxygen content control **3** indicated by two number threes each in a circle. The present system utilizes control vector separation and isolation for cleaner operation and more fuel efficiency, having three separate controls operated independently.

[0031] The fan speed control **1** comprises an induced draft fan **70** with fan blades **72** adjacent to and communicating with the exhaust stack **80**, the induced draft fan communicating with air flow through a biomass gasification furnace including through a fuel supply **25**, through a gasification chamber **20** producing pyrolitic gases **33**, through a blast tube burner **30** oxidizing the pyrolitic gases and generating a fire blast jet **31**, and out an exhaust stack **80**. A variable speed motor **73** drives the induced draft fan **72** in response to a boiler or other device load requirement control communicating with the induced draft fan to control the induced draft fan speed so that as the boiler or other device demand goes up the fan speed increases to draw more air through the entire gasification furnace to create more pyrolitic gases **33** to oxidize and create more heat, and as the heat demand goes down, the fan speed decreases to reduce air flow to reduce pyrolitic gas production and reduce heat, to optimize the heat production to meet demand efficiently without wasting heat when demand is reduced.

[0032] The induced draft fan **70** is capable of varying speed and is sufficiently large to create a negative pressure in the entire system, thereby controlling the flow of gases through the system.

[0033] A fuel pile level control **2** comprises a fuel pile height indicator **17** communicating with a multiple fuel screw feed mechanism **15** powered by a screw drive motor **18**, the level control **19** being set at a desired fuel pile **25** height for optimum fuel consumption and gas producing rate for the type of fuel and heat application device employed, so that whenever the fuel pile height decreases, the fuel screw feed mechanism is activated to increase fuel input and when the fuel height is at the desired fuel height, the feed mechanism is deactivated to maintain optimum fuel consumption and gas producing rate.

[0034] The system uses either a mechanical or electronic, internal or external, fuel pile height indicator device, depending on the model. The fuel pile is maintained to within a few centimeters of the desired level. As fuel is used up, the feed rate goes up, as the pile reaches the desired level the feed rate slows down. The system does not care what the fuel value of the material is; i.e. moisture content, mineral content, or particle size.

[0035] An oxygen content control **3** comprises a primary air feed **44** to the gasification chamber **20** and a secondary air feed **45** to the blast tube burner **30**; each having controls for opening and closing the air feeds; a first oxygen sensor **41** adjacent to a gasification chamber exit opening for sensing oxygen content of pyrolitic gases **33** entering the blast tube burner **30**; a second oxygen sensor **47** adjacent to a blast tube burner exit opening for sensing oxygen content of heated exhaust, both oxygen sensors constantly monitoring the gases for oxygen content and both communicating with the controls for opening and closing the dampers to maintain oxygen content control for constant combustion balance and air feed control.

[0036] A means for controlling a flow of air into the gasification chamber and into the blast tube burner **30** comprises an adjustable air valve **42** controlling the flow of air Al from outside the heating system through an air intake conduit **40**, and further comprises an adjustable damper **44** for directing and varying the rate of flow of the primary air **23** through a primary air conduit **48** which communicates with the gasification chamber **20** underneath the fuel bed grate and an adjustable damper **45** for directing and varying the rate of flow of secondary air through an angled burner air inlet conduit **46** into the blast tube burner **30**.

[0037] The fan speed control **1**, the fuel pile level control **2**, and the oxygen content control **3** each acting independently of each other to provide a separation and isolation of these controls to enable a clean, fuel efficient, and low polluting operation of the biomass gasification furnace, to enable use of a variety of fuel value and particle size fuel materials, and to enable efficient carbon utilization both in the gasification chamber and in the blast tube burner.

[0038] It is understood that the preceding description is given merely by way of illustration and not in limitation of the invention and that various modifications may be made thereto without departing from the spirit of the invention as claimed.

What is claimed is:

1. A three independent vector control system for a biomass gasification furnace utilizing control separation and isolation for cleaner operation and more fuel efficiency, the system utilizing three separate controls operated independently, the system comprising:

a fan speed control comprising at least one induced draft fan communicating with an exhaust stack of a biomass gasification furnace, the at least one induced draft fan controlling air pressure and air flow through the entire biomass gasification furnace including through a fuel supply, through a gasification chamber producing pyrolitic gases, through a blast tube burner oxidizing the pyrolitic gases and generating a fire blast jet, and out the exhaust stack; variable speed drives for the at least one induced draft fan; and a heat demand device indicating a load requirement controlling the induced draft fan speed so that as the heat demand goes up, the fan speed increases to draw more air through the entire gasification furnace to create more pyrolitic gases to oxidize and create more heat, and as the heat demand goes down, the fan speed decreases to reduce air flow to reduce pyrolitic gas production and reduce heat, to optimize the heat production to meet demand efficiently without wasting heat when demand is reduced;

a fuel pile level control comprising a fuel pile height indicator communicating with at least one fuel screw feed mechanism, the level control being set at a desired fuel pile height for optimum fuel consumption and gas producing rate for the type of fuel and heat application device employed, so that whenever the fuel pile height decreases, the fuel screw feed mechanism is activated to increase fuel input, and when the fuel height is at the desired fuel height, the feed mechanism is deactivated, to maintain optimum fuel consumption and gas producing rate for any of a wide variety of solid biomass fuels;

an oxygen content control comprising a primary air feed damper to the gasification chamber and a secondary air feed damper to the blast tube burner; controls for opening, closing, and adjusting quantity of air through the air feed dampers; a first oxygen sensor adjacent to a gasification chamber exit opening for sensing oxygen content of pyrolitic gases entering the blast tube burner; a second oxygen sensor adjacent to a burner exit opening for sensing oxygen content of heated exhaust entering the heat exchange chamber; both oxygen sensors constantly monitoring the gases for oxygen content and both communicating with the controls for opening, closing, and adjusting the air feed dampers to maintain constant oxygen content control for combustion balance and damper control for efficient carbon utilization;

the fan speed control, the fuel pile level control, and the oxygen content control each acting independently to provide a separation and isolation of these controls to enable optimum efficiency of the biomass gasification furnace to provide a clean, fuel efficient, and low polluting operation of the biomass gasification furnace, to enable use of a variety of fuel value and particle size fuel materials, and to enable efficient carbon utilization both in the gasification chamber and in the blast tube burner.

2. The system of claim **1** wherein the fuel pile height indicator comprises at least one height indicator taken from the list of height indicators including a mechanical indicator, an electronic indicator, an internal indicator, an external indicator, and a gamma ray indicator.

* * * * *