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(54) SYSTEM AND METHOD FOR GASIFYING A LIQUID SUBSTRATE

(57) A system for gasifying a liquid substrate which comprises a gasification tank, means for pumping a liquid substrate into the gasification tank, wherein said liquid substrate comprises a liquid fraction and solid fuel particles dissolved and/or in suspension in said liquid fraction; an injection tube connected to the gasification tank for injecting a liquid substrate into the gasification tank; a control valve positioned in the injection tube; a first gasifying agent inlet to the interior of the gasification tank, said first inlet comprising a burner, wherein at least one part of the gases forming said gasifying agent are burned; a tube for conducting fuel gas obtained as a product of the gasification of the liquid substrate.

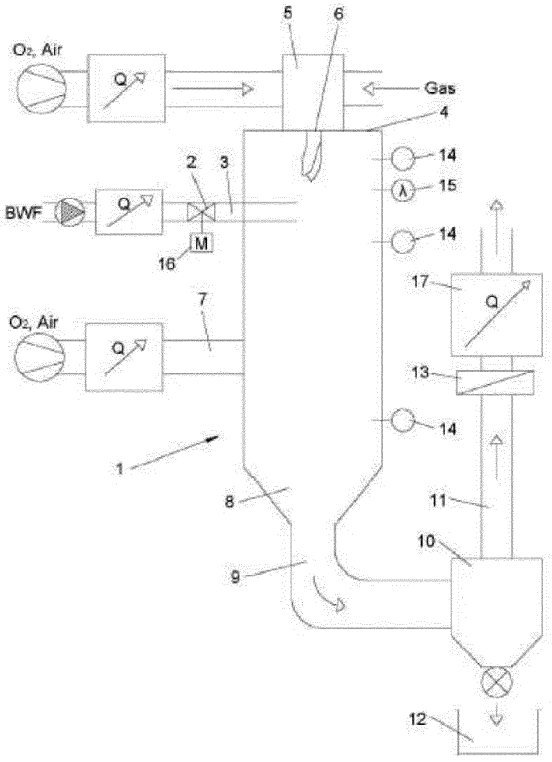

FIG. 1

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Description

Object of the invention

[0001] The present disclosure presents a system for gasifying a fuel formed by a liquid substrate which comprises a dilution or suspension of solid fuel particles.

[0002] The present disclosure also presents a method for gasifying a fuel formed by said liquid substrate which comprises a dilution or suspension of solid fuel particles.

[0003] It has an application in the industry dedicated to the design, manufacture, installation and operation of fuel gasification systems intended to obtain optimized fuels for the subsequent burning thereof at points for generating electric, mechanical and/or calorific energy.

Technical problem to be resolved and background of the invention

[0004] Gasification is a thermochemical process which strives to obtain a fuel, generally a gaseous fuel by means of applying a gasifying agent at high temperature to a carbonaceous substrate.

[0005] As a function of the type of substrate used, the temperature of the process in which the thermochemical reactions take place and the nature of the gasifying agent used, fuel gases are obtained as products, the compositions of which vary, it being common to encounter variable quantities of carbon monoxide and dioxide, hydrogen, methane and other hydrocarbons therein.

[0006] The fuel gas obtained by means of the gasification process is collected in the upper part of a gasifier or gasification tank by means of gas outlets provided with valves and filters to eliminate solids in suspension which ascend together with the final gaseous current as well as to filter certain residual gases of the process or gases which are obtained as by-products of said process.

[0007] One of the main drawbacks which is observed in the present gasification processes is obtaining an undesired solid by-product of the gasification process, resulting from the initial pyrolysis which the part of the substrate undergoes when it is heated in an oxygen-poor environment; said by-product is called "char" and although other secondary applications may be found for said by-product, obtaining it is considered an undesired secondary effect of the gasification process.

[0008] At the same time, during the entire gasification process, determined quantities of tar of variable composition are obtained as undesired by-products, together with solid and ash precipitates which form nuisance clumps at the base of the gasifiers and which must subsequently be removed and the gasifier cleaned.

Description of the invention

[0009] With the aim of avoiding the previously mentioned drawbacks related to the generation of undesired by-products of the gasification process, a gasification system and method are presented which are described below.

[0010] A fundamental characteristic of the gasification system which is presented is that it is designed for working with a liquid substrate instead of a solid substrate.

[0011] Said liquid substrate is formed by a liquid fraction (a liquid substance or mixture) with a variable quantity of dissolved solids or solids in suspension, fuel solids with a variable calorific power which, by means of the gasification process, are converted for the subsequent utilization thereof as a gaseous fuel.

[0012] The present gasification system preferably uses as a substrate a liquid mixture like the one described in the Spanish patent application ES 2457073 A1, of the type known as biocoal water fuel (BWF) or hydro char slurry (HCS).

[0013] Said mixture consists of a liquid substrate which comprises a determined quantity of solid fuel particles which are ground to obtain a particle size preferably lower than 200 microns and more preferably lower than 100 microns.

[0014] Following the grinding into small solid fuel particles, said particles are mixed with a liquid, preferably water, thus obtaining an aqueous substance with solid fuel particles dissolved or in suspension.

[0015] According to an alternative embodiment, the solid fuel particles can be mixed with a liquid different to water, for example an organic substance or solution. The organic substances (e.g. ethanol) provide the liquid substrate with specific properties in terms of the boiling, freezing or ignition point thereof which may be interesting as a function of the conditions of the gasification process.

[0016] The aqueous mixtures of solid fuels have the advantages, in logistical terms, of being capable of being pumped (in comparison to purely solid fuels), in addition to presenting reduced or zero flammability.

[0017] The gasification system of a liquid substrate, which is presented, comprises, according to a preferred embodiment of the same, a gasification tank which also comprises:

- means for pumping a liquid substrate into the gasification tank;
- an injection tube connected to the gasification tank for injecting a liquid substrate into the gasification tank;
- a control valve positioned in the injection tube to the gasification tank;
- a first gasifying agent inlet to the interior of the gasification tank;
- a conduction tube of fuel gas obtained as a product of the gasification of the liquid substrate.

[0018] The injection tube discharges into the gasification tank at a point where the temperature of the gasifying agent is such that the total or partial evaporation of the liquid fraction of the liquid substrate is produced. Preferably, said temperature is substantially equal to or greater

than 400 °C.

[0019] According to a preferred embodiment of the gasification system, the injection tube connects to the gasification tank in the upper part of said gasification tank, together with the upper end of said gasification tank.

[0020] At the same time, according to a preferred embodiment of the gasification system, the first gasifying agent inlet is located at the upper end of the gasification tank, above the injection tube of the liquid substrate.

[0021] The first gasifying agent inlet is preferably arranged in a vertical position, projecting a jet of gasifying agent in the vertical direction downwards to the interior of the gasification tank.

[0022] According to an embodiment of the gasification system, the first gasifying agent inlet comprises a burner wherein at least one part of the gases forming said gasifying agent is burned.

[0023] This is because sometimes the gasifying agent comprises a certain quantity of fuel gas which can be the fuel gas itself obtained as a product of the gasification process of the liquid substrate. Therefore, it may be convenient, in terms of increasing the temperature of the liquid substrate for the subsequent gasification thereof, to burn a part of the gases forming the gasifying agent in the mentioned burner.

[0024] The injection tube according to a preferred embodiment of the gasification system sprays and injects the liquid substrate in the horizontal direction into the interior of the gasification tank.

[0025] According to an embodiment of the gasification system, the system comprises a second gasifying agent inlet into the interior of the gasification tank, preferably situated below the injection tube of the liquid substrate.

[0026] The gasification tank comprises a base connected to a collection tube for circulating both the fuel gas obtained as a product of the gasification of the liquid substrate and solid residues generated during the gasification process.

[0027] According to a preferred embodiment of the gasification system of a liquid substrate, the system comprises a separation device connected both to the collection tube and to the conduction tube of the fuel gas, wherein said separation device is connected, by the lower part thereof, to an ashtray vessel.

[0028] Said separation device, which may comprise a cyclone, helps to separate possible ashes and/or solid residues which may have been generated during the gasification or which may entrain with them the liquid substrate from the inlet thereof into the gasification tank.

[0029] According to a possible embodiment of the gasification system, the conduction tube is connected to a gas filter for separating undesired gases and/or residual solids from the fuel gas obtained as a product of the gasification of the liquid substrate.

[0030] At the same time, according to a possible embodiment of the gasification system, the conduction tube connects to a system for rinsing the fuel gas obtained as a product of the gasification of the liquid substrate.

[0031] Preferably, the conduction tube connects to a first heat exchanger for utilizing thermal energy contained in the fuel gas obtained as a product of the gasification of the liquid substrate.

[0032] The gasification system of a liquid substrate comprises, according to a preferred embodiment, at least one temperature probe situated in the interior of the gasification tank.

[0033] Preferably, the system comprises at least three temperature probes located at different heights in the interior of the gasification tank.

[0034] The gasification system also comprises, according to a preferred embodiment of the same, at least one measurement probe of the oxygen concentration situated in the interior of the gasification tank for measuring the quantity of oxygen contained in the gasifying agent.

[0035] According to a preferred embodiment of the system for gasifying a liquid substrate, the system comprises at least one servomotor connected to a control valve of the injection tube.

[0036] As has already been put forward, the present disclosure also relates to a method for gasifying a liquid substrate which comprises solid fuel particles dissolved and/or in suspension.

[0037] According to a preferred embodiment of the method for gasifying a liquid substrate, the method comprises:

- introducing a determined quantity of liquid substrate within a current of hot gasifying agent wherein said gasifying agent comprises any combination of at least the following constituents:
    - ◦ air;
    - ◦ oxygen;
    - ◦ water vapor;
    - ◦ carbon dioxide;
    - ◦ hot gases coming from external combustion processes;
    - ◦ fuel gases (e.g. obtained as a product of the gasification of the liquid substrate according to the present method);
- increasing the temperature of the liquid substrate until the evaporation of the liquid fraction of the liquid substrate is produced.
- gasifying the solid fuel particles of the liquid substrate;
- collecting the fuel gas obtained as a product of the gasification of the liquid substrate.

[0038] The method comprises pressurizing the liquid substrate prior to the introduction thereof within a current of gasifying agent.

[0039] The liquid substrate is preferably pressurized up to a pressure equal to or greater than the evaporation pressure (corresponding to a determined temperature at which the liquid substrate is found) of the liquid fraction

contained in said liquid substrate.

[0040] The method comprises, according to an embodiment of the same, preheating the liquid substrate prior to the introduction thereof within a current of gasifying agent.

[0041] According to a preferred embodiment of the gasification method of a liquid substrate, the method comprises spraying the liquid substrate in small drops, injecting them within the current of gasifying agent.

[0042] The gasification method preferably comprises carrying out heating of the gasifying agent, wherein said heating comprises at least the following steps:

- a first step consists of heating the gasifying agent to a temperature substantially equal to or greater than 400 °C prior to the introduction thereof within the gasifying agent of a determined quantity of liquid substrate;
- a second step consists of heating the gasifying agent to a temperature of between 700 °C and 1,400 °C.

[0043] Owing to the preheating of the gasifying agent to a temperature equal to or greater than 400 °C, the evaporation of a large part of the liquid fraction of the liquid substrate is enabled.

[0044] In the second heating step of the gasifying agent, said gasifying agent is preferably heated to a temperature of between 1,000 °C and 1,200 °C in order to avoid the formation of char and tar during the gasification of the liquid substrate and in order to avoid the clumping of the ashes which the liquid substrate may entrain with it from the start.

[0045] In the cases in which the gasifying agent comprises fuel gases (e.g. coming from the gasification process of the liquid substrate itself), the heating of the gasifying agent in the first step can already be carried out in the interior of the gasification tank by means of combustion in a burner, situated corresponding to the first gasifying agent inlet, of the part of the gases which form part of the gasifying agent.

[0046] In the mentioned case in the previous paragraph, the fuel gases are mixed with air and/or oxygen to form said gasifying agent and after combustion in the burner, the hot gasifying agent emerges (temperature preferable greater than 400 °C).

[0047] The burning of at least one part of the constituents of the gasifying agent is preferably produced prior to the introduction of the liquid substrate within the gasifying agent.

[0048] As has already been mentioned, the gasifying agent may also comprise hot gases resulting from the combustion of other external combustion processes which are mixed with air and/or oxygen to form said gasifying agent and which contribute to the heating of said gasifying agent.

[0049] The injection of gasifying agent by way of a second gasifying agent inlet may help to adjust the temperature of the gasifying agent between 1,000 °C and 1,200 °C.

[0050] The method preferably comprises separating ashes and/or solid residues from the fuel gas obtained as a product of the gasification of the liquid substrate.

[0051] According to a possible embodiment of the method for gasifying a liquid substrate, the method comprises filtering the fuel gas obtained as a product of the gasification of the liquid substrate.

[0052] Preferably, the method comprises circulating the fuel gas obtained as a product of the gasification of the liquid substrate through a first heat exchanger to utilize the thermal energy (contained in the fuel gas) for other processes.

[0053] According to a possible embodiment of the method for gasifying a liquid substrate, the method comprises circulating the liquid substrate through the mentioned first heat exchanger prior to the introduction of the liquid substrate within the current of gasifying agent. In this way, the preheating of the liquid substrate can be achieved before injecting it within the current of gasifying agent.

[0054] As has already been put forward, according to an embodiment of the gasification method, the method comprises mixing at least one part of the fuel gas obtained as a product of the gasification of the liquid substrate with air or oxygen. Following the combustion of the mixture of the gases, a gasifying agent with a high temperature is obtained, within which a determined quantity of liquid substrate is introduced to firstly evaporate the liquids and initiate the pyrolysis and gasification of the solid particles.

[0055] According to a preferred embodiment of the method for gasifying a liquid substrate, the method comprises measuring the temperature of the gasifying agent during the gasification of said liquid substrate at least once and at at least one point of an area where the gasifying agent and the liquid substrate are mixed.

[0056] The method preferably comprises controlling and regulating (maintaining/increasing/decreasing) the temperature and/or the quantity of oxygen contained in the gasifying agent as a function of the measured temperature of the gasifying agent.

[0057] According to an embodiment of the gasification method, said regulating may be carried out by means of controlling a burner, in which part of the gases composing the gasifying agent are burned and/or by means of controlling the inlet of gasifying agent by way of a second gasifying agent inlet.

[0058] According to a preferred embodiment of the method for gasifying a liquid substrate, the method comprises measuring at least once and at at least one point of an area where the gasifying agent and the liquid substrate are mixed the quantity of oxygen contained in the gasifying agent.

[0059] The method preferably comprises controlling and regulating (maintaining/increasing/decreasing) the quantity of oxygen contained in the gasifying agent as a function of the quantity of oxygen measured in the gas-

ifying agent.

[0060] A particular embodiment of the method for gasifying a liquid substrate is presented below.

[0061] According to said embodiment, the method for gasifying a liquid substrate comprises:

- preheating the gasifying agent;
- introducing a current of gasifying agent into a gasification tank by way of a first gasifying agent inlet;
- preheating a liquid substrate which comprises solid fuel particles dissolved and/or in suspension;
- pressurizing the liquid substrate to a pressure equal to or greater than the vapor pressure of the liquid fraction of the liquid substrate (vapor pressure corresponding to the preheating temperature of the liquid substrate);
- injecting inside the gasification tank and by way of an injection tube, the liquid substrate within the current of gasifying agent, wherein the liquid substrate is sprayed in small drops which are dispersed in the current of gasifying agent;
- regulating the temperature of the gasifying agent and the pressurization of the liquid substrate to evaporate the liquid fraction of the liquid substrate through the effect of a temperature increase and a pressure decrease of the liquid substrate;
- regulating the temperature and the quantity of oxygen of the gasifying agent to gasify the solid fuel particles of the liquid substrate by means of thermochemical reaction with the gasifying agent;
- collecting in a collection tube connected to a base of the gasification tank, the fuel gas, product of the gasification of the liquid substrate, together with possible ashes and/or solid residues;
- separating in a separation device (for example, a cyclone) ashes and/or solid residues from the fuel gas obtained as a product of the gasification of the liquid substrate;
- circulating the fuel gas obtained as a product of the gasification of the liquid substrate through a first heat exchanger to utilize the thermal energy of the fuel gas. If the gases are cooled below the condensation temperature of water, the latent heat can be recovered from the water vapors contained in the gases. The thermal recovery may be significant taking into account the high water vapor content coming from the injection of liquid substrate.

[0062] The gasifying agent is introduced into the gasification tank at a minimum temperature of approximately 400 °C. This preheating can be achieved by means of any combination of at least the following measures:

- a provision of heat to the gasifying agent prior to the introduction thereof into the gasification tank;
- incorporating hot gases coming from an external combustion process into the gasifying agent;
- incorporating fuel gases, which are burned at the inlet of the gasifying agent into the gasification tank, into the gasifying agent.

[0063] The liquid substrate is preheated preferably making it circulate prior to the introduction thereof into the gasification tank through a first heat exchanger. In this way, it utilizes the heat which the fuel gas obtained as a product of the gasification of the liquid substrate transfers to it.

[0064] The mentioned first heat exchanger is preferably tubular.

[0065] The mentioned gasification tank preferably has an elongated tubular geometry.

[0066] Preferably, the method also comprises introducing a gasifying agent by way of a second gasifying agent inlet into the gasification tank, said second inlet preferably being situated below the injection tube.

[0067] The gasification method preferably comprises measuring the temperature at at least three points along the gasification tank.

Brief description of the figures

[0068] As part of the description of the embodiment of the invention, a series of figures have been included, the description of which is as follows:

Figure 1 shows a schematic view of an exemplary embodiment of the gasification system of a liquid substrate object of the present disclosure.

Figure 2 shows a flow diagram of an exemplary embodiment of the method for gasifying a liquid substrate, object of the present disclosure.

Detailed description

[0069] The present disclosure relates, as has been previously mentioned, to a system and to a method for gasifying a liquid substrate.

[0070] Figure 1 shows a schematic view of an exemplary embodiment of the system for gasifying a liquid substrate.

[0071] According to a preferred embodiment of the system for gasifying a liquid substrate, said system comprises a gasification tank (1) connected to a tube for injecting (3) the liquid substrate.

[0072] According to a preferred embodiment of the gasification system, the gasification tank (1) comprises a vertical tubular geometry.

[0073] The tube for injecting (3) the liquid substrate comprises, at the entry thereof to the gasification tank (1), a control valve (2) of said liquid substrate.

[0074] Said control valve (2) with the injection tube (3) is designed to produce atomization or spraying in small drops of the liquid substrate into the interior of the gasification tank (1). Said atomization is produced due to the partial evaporation of the liquid substrate which enters with a determined temperature and pressure into the con-

trol valve (2) and subsequent expansion of the vapors generated in the injection tube (3).

[0075] According to a preferred embodiment of the gasification system, the injection tube (3) connects to the gasification tank (1) in the upper part of said gasification tank (1), preferably a short distance from the upper end (4) of said gasification tank (1).

[0076] The gasification system also comprises, in the interior of the gasification tank (1), a first gasifying agent inlet (5), said first inlet (5) preferably located at the upper end (4) of the gasification tank (1) above the tube for injecting (3) the liquid substrate.

[0077] The first gasifying agent inlet (5) is preferably positioned in a vertical position such that a jet of gasifying agent projects in a vertical direction and downwards.

[0078] According to an embodiment of the gasification system, the system also comprises a burner (6) in the interior of the gasification tank (1), in the first gasifying agent inlet (5); according to said embodiment, in said burner (6) at least part of the gases forming the gasifying agent are burned, thus increasing the temperature of the gasifying agent and ultimately, the temperature of the liquid substrate.

[0079] In turn, according to a preferred embodiment of the gasification system, both the injection tube (3), in the interior section thereof to the gasification tank (1), and the control valve (2) of the liquid substrate are arranged in a position such that it allows them to project the sprayed liquid substrate into the interior of the flow of the gasifying agent into the interior of the gasification tank (1).

[0080] According to a possible embodiment of the system for gasifying a liquid substrate, the system comprises a second gasifying agent inlet (7) in the interior of the gasification tank (1) wherein said second gasifying agent inlet (7) is situated below the tube for injecting (3) the liquid substrate.

[0081] According to a preferred embodiment of the system for gasifying a liquid substrate, the gasification tank (1) comprises a base (8) connected to a collection tube (9) through which circulates both the fuel gas obtained as a product of the gasification process and any possible solid residue which may have been either generated during the gasification process or which the liquid substrate brought with it upon entering the gasification tank.

[0082] Said collection tube (9) connects to a separation device (10) for separating the fuel gas obtained as a product of the gasification process from ashes and/or other solid residues, wherein the separation device (10) connects at the upper part thereof to a conduction tube (11) of the fuel gas obtained as a product of the process, connecting at the lower part thereof to an ashtray vessel (12) for collecting possible solid residues, either generated during the gasification process or entrained together with the liquid substrate upon it entering the gasification tank (1).

[0083] According to a possible embodiment of the gasification system, the separation device (10) comprises a cyclone for separating ashes and/or other solid residues from the fuel gas obtained as a product of the gasification process.

[0084] According to a preferred embodiment of the gasification system, the conduction tube (11), in turn, connects to a gas filter (13) for separating possible undesired gases which circulate together with the current of fuel gas as well as possible solid residues, entrained together with the current of fuel gas obtained as a product of the gasification process.

[0085] At the outlet of the gas filter (13), the conduction tube (11), in turn, connects to a storage tank for the fuel gas, or either to a system for rinsing said fuel gas or to a system for utilizing said fuel gas, utilization which may result from using the fuel gas to obtain electric, mechanical or thermal energy.

[0086] The system for gasifying a liquid substrate comprises, according to a preferred embodiment of the same, at least one temperature probe (14) situated in the interior of the gasification tank (1).

[0087] According to a preferred embodiment, the gasification system comprises at least three temperature probes (14) located at different heights in the interior of the gasification tank (1).

[0088] The system also comprises, according to a preferred embodiment, at least one measurement probe (15) of the quantity of oxygen (also called "lambda probe") contained in the gasifying agent.

[0089] Moreover, according to a preferred embodiment of the gasification system, the system comprises at least one servomotor (16) connected to a control valve (2).

[0090] According to an embodiment of the gasification system, the system comprises at least one first heat exchanger (17) to which the conduction tube (11) connects to utilize the thermal energy contained in the fuel gas obtained as a product of the process. Said thermal energy may be used to preheat the liquid substrate and/or the gasifying agent prior to the introduction thereof into the gasification tank (1).

[0091] As has been mentioned previously, the present disclosure also relates to a method for gasifying a liquid substrate.

[0092] Figure 2 shows a schematic flow diagram with the different phases forming the method for gasifying a liquid substrate according to an embodiment of said method. Said phases are listed below:

- preheating gasifying agent (21);
- introducing (22) gasifying agent into a gasification tank (1);
- pressurizing (24) liquid substrate;
- preheating liquid substrate (23);
- injecting (25) liquid substrate into the gasification tank (1);
- regulating the temperature of the gasifying agent and the pressure of the liquid substrate to evaporate (26) the liquid fraction of the liquid substrate;
- regulating the quantity of oxygen and the tempera-

ture of the gasifying agent to gasify (27) the solid fuel particles of the liquid substrate;

- separating (28) ashes and/or solid residues from the fuel gas obtained as a product of the gasification;
- circulating (29) the fuel gas obtained as a product of the gasification through a first heat exchanger (17) to utilize the thermal energy of the fuel gas.

[0093] According to a preferred embodiment of the gasification method, the method comprises pressurizing a mixture of liquid substrate which comprises a determined quantity of solid fuel particles dissolved or in suspension.

[0094] Moreover, according to a preferred embodiment of the method, the method comprises preheating the mixture of liquid substrate. The preheating is preferably produced by means of a heat exchanger, preferably tubular, and preferably using residual heat from the gasification process, heat recovered from the gases obtained as products of the process.

[0095] The pressurization of the liquid substrate preferably comprises increasing the pressure of said liquid substrate to a pressure equal to or greater than the evaporation pressure of the liquid fraction contained in the liquid substrate at the preheating temperature.

[0096] The gasification method comprises, according to a preferred embodiment of the same, introducing a current of a gasifying agent into a gasification tank (1).

[0097] According to an embodiment of the gasification method, said gasifying agent comprises combustion gases, whether they are from external combustion processes or coming from the combustion in a burner (6) of part of the gas (syngas) obtained as a product of the gasification process.

[0098] The gasifying agent preferably has a temperature greater than 400 °C in the upper part of the gasification tank (1). In this way, the evaporation of the liquid fraction of the liquid substrate is achieved.

[0099] According to an embodiment of the gasification method, the heat provided with the gasifying agent and the heat generated in the gasification process itself is regulated with the quantity of oxygen provided with the gasifying agent to obtain a gasification temperature of between 700 °C and 1,400 °C. In this way, the pyrolysis of the solid fraction of the liquid substrate is produced. By means of the corresponding thermochemical reactions, the gasification of the solid particles contained in the liquid substrate and dispersed following the evaporation of the liquid fraction of the liquid substrate is produced.

[0100] Said gasification temperature is preferably regulated in the range between 1,000 °C and 1,200 °C to avoid the emergence of char and tar which principally takes place at temperatures lower than said range and in order to similarly avoid the melting of ashes entrained with the liquid substrate (ashes which initially accompany the BWF particles), melting which principally takes place at temperatures greater than said range.

[0101] In order to control the temperature of the gasification process, a second supply of said gasifying agent is produced by way of a second gasifying agent inlet (7) which provides additional oxygen into the interior of a gasification tank (1).

[0102] The gasifying agent comprises a variable quantity of air and/or pure oxygen. In the case that the gasifying agent is mixed with gases coming from a combustion process (e.g. from the combustion of the gas generated as a product of the gasification process), said gasifying agent can also comprise any combination of carbon monoxide and carbon dioxide. The gasifying agent also comprises water vapor which is generated upon the liquid fraction of the liquid substrate evaporating. Additionally, the gasifying agent can comprise a mixture of other gases.

[0103] The gasifying agent preferably comprises an excess of oxygen to provide the stoichiometric quantity necessary for the gasification reactions of the liquid substrate.

[0104] According to an embodiment of the gasification method, the gasifying agent can comprise combustion products of part of the gas obtained as a product of the gasification process, combustion which can be produced in a burner (6), helping to thereby increase the temperature of the gasifying agent and ultimately the temperature of the liquid substrate by means of the heat generated in said combustion.

[0105] According to a preferred embodiment of the gasification method, said method comprises introducing the preheated mixture of liquid substrate within a current of gasifying agent.

[0106] The gasification method also comprises, according to a preferred embodiment of the same, spraying, in small drops, said liquid substrate within the current of gasifying agent, wherein the gasifying agent is at a temperature sufficient to produce the evaporation of the liquid fraction of the liquid substrate and the gasification of the solid particles of the liquid substrate.

[0107] Due to the temperature conditions and oxygen content in the gasifying agent, a pyrolysis process is initiated which breaks down the small solid particles provided in the liquid substrate and discharges into a gasification process. If the gasification temperature is not sufficiently high, char and tar may form as by-products of the gasification. By means of providing air and/or pure oxygen in a first gasifying agent inlet (5) and/or in a second gasifying agent inlet (7) into the interior of a gasification tank (1), the gasification temperature may be increased to the level required to avoid the formation of char and/or tar. In the case of complete gasification, at the end of the gasification process, only ashes such as residual solids remain and a syngas principally composed of H, CO, CO_2, H_2O, N and others components which have been provided with the gasifying agent or which may have been produced during the thermochemical reactions.

[0108] According to a preferred embodiment of the

gasification method, the method comprises introducing the preheated, pressurized and sprayed mixture of liquid substrate into the gasification tank (1) into which the preheated gasifying agent is introduced within a jet of gasifying agent.

[0109] The method comprises, according to a preferred embodiment of the same, precipitating the liquid substrate within the gasifying agent such that, during the precipitation of the drops of the liquid substrate, the thermochemical reactions themselves of the gasification of said liquid substrate are produced.

[0110] When the liquid substrate passes through the control valve (2), an abrupt decrease of the pressure of said liquid substrate is produced when it enters into contact with the interior environment of the gasification tank (1).

[0111] Said pressure decrease, coupled with the provision of heat in the injection tube (3), produce the evaporation of a part of the liquid fraction (principally water) which forms the drops of the liquid substrate.

[0112] When the fine drops of liquid substrate are heated during the precipitation thereof within the gasifying agent, the entire liquid fraction remaining from said liquid substrate drops is ultimately evaporated, leaving only the solid fuel particles which the liquid substrate initially contained.

[0113] The water vapor generated then becomes part of the gasifying agent. The gasification process means that a certain quantity of hydrogen is also generated from said water vapor.

[0114] The evaporation of all the liquid, coupled with the fact of being embedded within the gasifying agent, facilitates the dispersion of the solid fuel particles within said gasifying agent, thus preventing clumps of fuel, aiding better gasification of the entire substrate and preventing the formation of final solid by-products in the process.

[0115] The solid particles, in the precipitation thereof within the hot gasifying agent, are going to undergo different thermochemical reactions, passing through intermediate solid products until ultimately a syngas is obtained as a product of the gasification process, said syngas comprising, amongst other gases, hydrogen, carbon monoxide, carbon dioxide, methane and a certain amount of water vapor.

[0116] The inorganic content of the solid particles of the substrate (Fe, Ca, K, amongst others, contained in the ashes entrained in the BWF) catalyzes the thermochemical reactions itself of the gasification (facilitating the cracking of the carbon chains) and ultimately reacts with the char which inevitably is produced during the gasification (although in a lower quantity than in conventional gasification, owing to the use of liquid substrate and to the dispersion thereof in the gasifying agent) forming ashes as a by-product which precipitate and are extracted from the gasification tank (1).

[0117] According to an embodiment of the gasification method, said ashes can be extracted by making the current of gas obtained as a product of the gasification process (syngas) pass through a static particle filter or through some type of separation device (10), such as a cyclone.

[0118] The current of gas obtained as a product of the process is made to pass, according to an embodiment of the gasification method, through a first heat exchanger (17) to utilize the thermal energy of said gas.

[0119] The heat extracted by means of the first heat exchanger (17) from the current of gas obtained as a product of the process may be utilized, for example for preheating the liquid substrate and/or the gasifying agent used in the gasification process, thus improving the energetic balance of the process.

[0120] If the temperature of the gas obtained as a product of the gasification process were not sufficiently high so as to utilize it for preheating the liquid substrate and/or the gasifying agent, the thermal energy of said gas obtained as a product of the gasification process may be utilized for other types of processes which do not require such a high temperature level (e.g. for the use thereof in heating systems).

[0121] Ultimately, according to an embodiment of the method for gasifying a liquid substrate, the gas obtained as a product of the process is subjected to a rinsing process to eliminate possible undesired solid and/or gaseous residues, ultimately obtaining a current of gas (syngas), product of the gasification process, the internal energy of which is utilized in other processes in order to obtain electric, mechanical or thermal energy.

[0122] According to a preferred embodiment of the gasification method, the method comprises measuring the quantity of oxygen contained in the jet of gasifying agent. Said measurement can be carried out at different points along the gasification tank (1). Said measurement is preferably carried out at at least one point situated before the injection of the liquid substrate into the gasification tank (1).

[0123] In this way, the quantity of gasifying agent required to be introduced into the gasification tank (1) for the complete gasification of the substrate to be produced can be controlled. More specifically, the concentration of oxygen which the gasifying agent has to have can thereby be controlled, increasing or reducing said oxygen concentration in the gasifying agent according to the requirements of the gasification process.

[0124] The gasification method preferably comprises introducing the gasifying agent into the interior of the gasification tank (1), at one point of said gasification tank (1) situated above the inlet of the liquid substrate sprayed into the gasification tank (1).

[0125] The gasification method also comprises, according to an embodiment of the same, introducing gasifying agent into at least two different points along the gasification tank (1).

[0126] According to said embodiment mentioned in the previous paragraph, gasifying agent is introduced into at least one point of the gasification tank (1) situated above the inlet of the sprayed liquid substrate and at at least one point of the gasification tank (1) situated below the

inlet of liquid substrate into said gasification tank (1).

[0127] The gasification method comprises, according to an embodiment of the same, measuring the temperature at at least one point of the interior of the gasification tank (1).

[0128] According to a preferred embodiment of the gasification method, the method comprises measuring the temperature at at least three points of the interior of the gasification tank (1), located at different heights along the gasification tank (1).

[0129] As a function of the temperature measured in the interior of the gasification tank (1), the quantity of gasifying agent to be provided and the concentration of oxygen in the gasifying agent are also controlled.

Claims

1. A system for gasifying a liquid substrate which comprises a gasification tank (1), **characterized in that** it also comprises:

   - means for pumping a liquid substrate into the gasification tank (1), wherein said liquid substrate comprises a liquid fraction and solid fuel particles dissolved and/or in suspension in said liquid fraction;
   - an injection tube (3) connected to the gasification tank (1) for injecting a liquid substrate into the gasification tank (1);
   - a control valve (2) positioned in the injection tube (3);
   - a first gasifying agent inlet (5) to the interior of the gasification tank (1), said first inlet (5) comprising a burner (6), wherein at least one part of the gases forming said gasifying agent are burned;
   - a tube for conducting (11) fuel gas obtained as a product of the gasification of the liquid substrate.

2. The system for gasifying a liquid substrate according to claim 1, **characterized in that** the injection tube (3) discharges into one point of the gasification tank (1), wherein the temperature of the gasifying agent is such that the total or partial evaporation of the liquid fraction of the liquid substrate is produced.

3. The system for gasifying a liquid substrate according to claim 2, **characterized in that** the temperature of the gasifying agent at the point where the injection tube (3) of the liquid substrate discharges into the gasification tank (1) is substantially equal to or greater than 400 °C.

4. The system for gasifying a liquid substrate according to claim 1, **characterized in that** it comprises a second gasifying agent inlet (7) to the interior of the gasification tank (1).

5. The system for gasifying a liquid substrate according to claim 1, **characterized in that** the gasification tank (1) comprises:

   - a base (8) connected to a collection tube (9) for circulating both the fuel gas obtained as a product of the gasification of the liquid substrate and solid residues generated during the gasification process;
   - a separation device (10) connected both to the collection tube (9) and to the conduction tube (11), wherein said separation device (10) is connected, by the lower part thereof, to an ashtray vessel (12) and the separation device (10) comprising a cyclone.

6. The system for gasifying a liquid substrate according to claim 1, **characterized in that** the conduction tube (11) is connected to a gas filter (13) for separating undesired gases and/or solid residues from the fuel gas obtained as a product of the gasification of the liquid substrate.

7. The system for gasifying a liquid substrate according to claim 1, **characterized in that** the conduction tube (11) connects to a system for rinsing the fuel gas obtained as a product of the gasification of the liquid substrate.

8. The system for gasifying a liquid substrate according to claim 1, **characterized in that** the conduction tube (11) connects to a first heat exchanger (17) for utilizing the thermal heat contained in the fuel gas obtained as a product of the gasification of the liquid substrate.

9. The system for gasifying a liquid substrate according to claim 1, **characterized in that** it comprises at least one temperature probe (14) situated in the interior of the gasification tank (1) and/or at least one measurement probe (15) situated in the interior of the gasification tank (1) for measuring the quantity of oxygen contained in the gasifying agent.

10. A method for gasifying a liquid substrate, **characterized in that** it comprises:

    - introducing a determined quantity of liquid substrate, which comprises solid fuel particles dissolved and/or in suspension within a current of gasifying agent wherein said gasifying agent comprises any combination of at least the following constituents:
      - air;
      - oxygen;

- water vapor;
- carbon dioxide;
- hot gases coming from external combustion processes;
- fuel gases;

- increasing the temperature of the liquid substrate until the evaporation of the liquid part of the liquid substrate is produced.
- gasifying the solid fuel particles of the liquid substrate;
- collecting fuel gas obtained as a product of the gasification of the liquid substrate;

wherein the method comprises heating the gasifying agent, wherein said heating comprises at least the following steps:

- a first step consists of heating the gasifying agent to a temperature substantially equal to or greater than 400 °C prior to the introduction within the gasifying agent of a determined quantity of liquid substrate;
- a second step consists of heating the gasifying agent to a temperature of between 700 °C and 1,400 °C.

11. The method for gasifying a liquid substrate according to claim 10, **characterized in that** it comprises:

- burning at least one part of the constituents of the gasifying agent prior to the introduction of the liquid substrate within the gasifying agent;
- pressurizing the liquid substrate prior to the introduction thereof within a current of gasifying agent to a pressure equal to or greater than the evaporation pressure, at a determined temperature, of the liquid fraction contained in the liquid substrate;
- preheating the liquid substrate prior to the introduction thereof within a current of gasifying agent;
- spraying the liquid substrate in small drops of liquid substrate, injecting them within the current of gasifying agent.

12. The method for gasifying a liquid substrate according to claim 10, **characterized in that** it comprises separating ashes and/or solid residues from the fuel gas obtained as a product of the gasification of the liquid substrate.

13. The method for gasifying a liquid substrate according to claim 10, **characterized in that** it comprises filtering the fuel gas obtained as a product of the gasification of the liquid substrate.

14. The method for gasifying a liquid substrate according to claim 10, **characterized in that** it comprises circulating the fuel gas obtained as a product of the gasification of the liquid substrate through a first heat exchanger (17) to utilize the thermal energy contained in the fuel gas for other processes.

15. The method for gasifying a liquid substrate according to claim 12, **characterized in that** it comprises:

- preheating gasifying agent (21);
- introducing (22) a current of gasifying agent into a gasification tank (1) by way of a first gasifying agent inlet (5);
- pressurizing (23) the liquid substrate to a pressure equal to or greater than the vapor pressure of the liquid fraction of the liquid substrate at a preheating temperature of the liquid substrate;
- preheating a liquid substrate (24) which comprises solid fuel particles dissolved and/or in suspension;
- injecting (25) the liquid substrate within the current of gasifying agent inside the gasification tank (1) by way of an injection tube (3), wherein the liquid substrate is sprayed in small drops which are dispersed in the current of gasifying agent;
- regulating the temperature of the gasifying agent and the pressurization of the liquid substrate to evaporate (26) the liquid fraction of the liquid substrate through the effect of a temperature increase and a pressure decrease of the liquid substrate;
- regulating the temperature and the quantity of oxygen of the gasifying agent to gasify (27) the solid fuel particles of the liquid substrate by means of a thermochemical reaction with the gasifying agent;
- collecting in a collection tube (9) connected to a base (8) of the gasification tank (1), fuel gas, product of the gasification of the liquid substrate, together with ashes and/or solid residues;
- separating (28) ashes and/or solid residues from the fuel gas obtained as a product of the gasification of the liquid substrate in a separation device (10);
- circulating (29) the fuel gas obtained as a product of the gasification of the liquid substrate through a first heat exchanger (17) to utilize the thermal energy of the fuel gas.

16. The method for gasifying a liquid substrate according to claim 15, **characterized in that** it comprises introducing gasifying agent into the gasification tank (1) by way of a second gasifying agent inlet (7) situated below the injection nozzle (3).

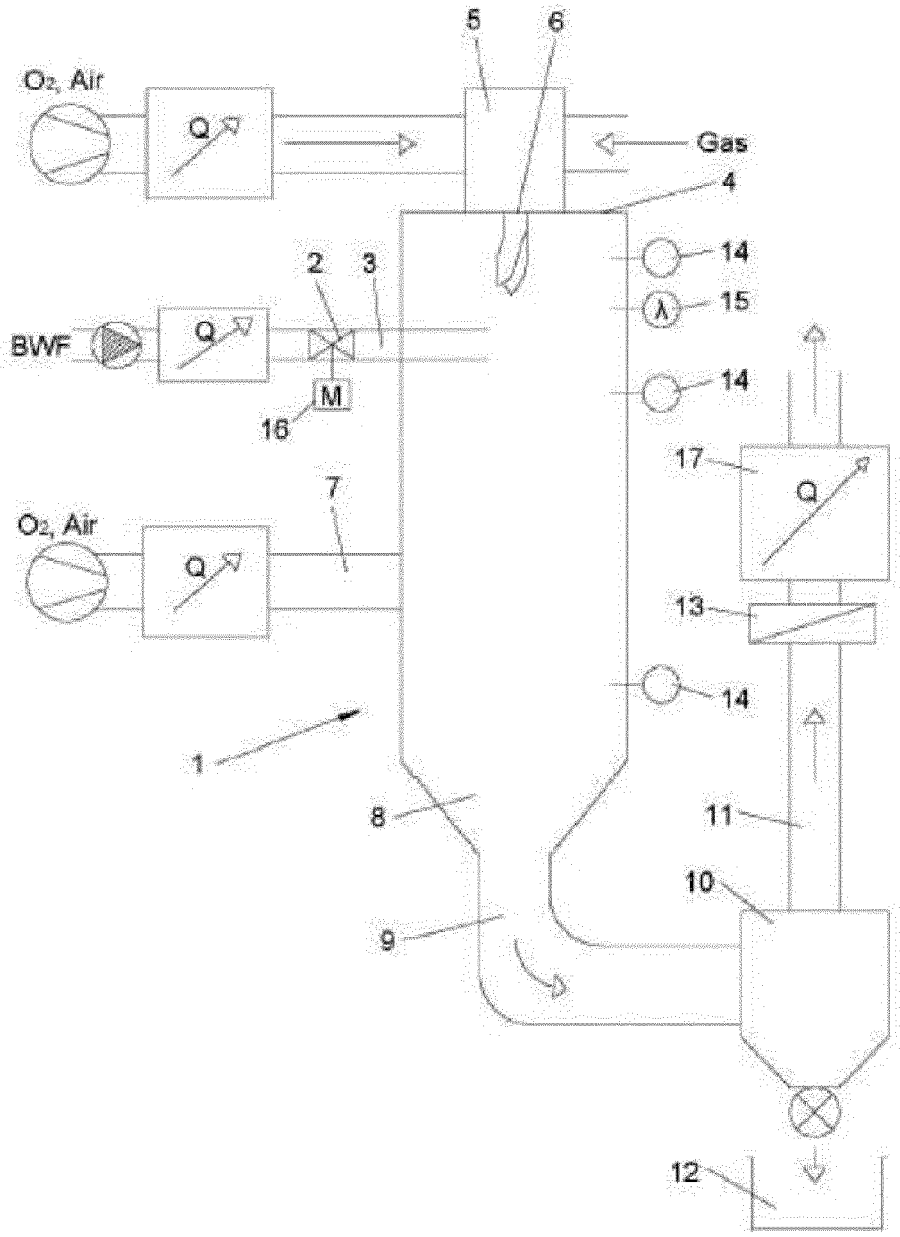
O2, Air
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FIG. 1

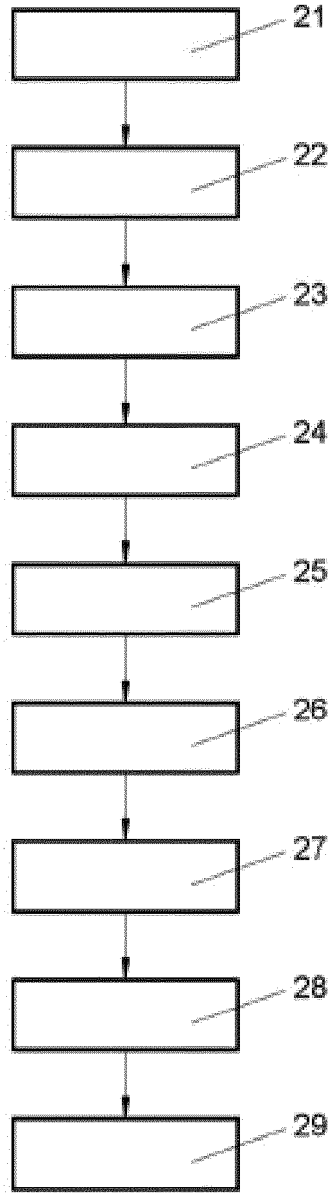

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 16 38 2127

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 328 006 A (MUENGER JAMES R ET AL) 4 May 1982 (1982-05-04)	1-8	INV.
			C10J3/72
Y	* figure 1 *	9	C10J3/50
A		10-16	C10J3/80

A	US 4 624 684 A (STEVENSON JOHN S [US]) 25 November 1986 (1986-11-25) * figure 1 *	1-16	

X	US 2011/179762 A1 (KIM HYUN YONG [KR]) 28 July 2011 (2011-07-28)	10-16	
A	* figures 3,4 *	1-9	

Y	US 2012/085028 A1 (LEININGER THOMAS FREDERICK [US]) 12 April 2012 (2012-04-12) * figures 1,2 *	9	

TECHNICAL FIELDS SEARCHED (IPC)

C10J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	19 August 2016	Lachmann, Richard

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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19-08-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4328006 A	04-05-1982	NONE	
US 4624684 A	25-11-1986	NONE	
US 2011179762 A1	28-07-2011	CN 101153557 A	02-04-2008
		KR 20070048149 A	08-05-2007
		US 2011179762 A1	28-07-2011
US 2012085028 A1	12-04-2012	AU 2011232808 A1	26-04-2012
		CA 2753736 A1	08-04-2012
		CN 102443444 A	09-05-2012
		CN 104711037 A	17-06-2015
		JP 2012082419 A	26-04-2012
		KR 20120036762 A	18-04-2012
		US 2012085028 A1	12-04-2012

EPO FORM P0459

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