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Method and Device for Producing Materials or Fuels

DESCRIPTION

Background of the Invention

[0001] The application relates to a method and apparatus for the production of materials or fuels, humus, Maillard or Maillard-like reaction products from a solid-fluid mixture of water and a carbon-containing component and for the treatment thereof, wherein the solid-fluid mixture is treated at a temperature of over 100° C. and a pressure of over 5 bar.

State of the Art

[0002] In 1913, Friedrich Bergius described the production of coal from wood or cellulose at temperatures between 245 and approximately 340° C. with exclusion of air in a laboratory reactor without the use of catalysts for the first time in his postdoctoral document "the use of high pressures in chemical processes and a reproduction of the development process of coal". The carbon contents measured in the elementary analysis were usually above 70%. A calculation of the exothermic reaction of cellulose carried out by Bergius in this process was essentially confirmed in July 2006 by Professor Markus Antonietti of the Max Planck Institute of Colloids and Interfaces in Potsdam, who introduced this method to the public in the laboratory scale with the name hydrothermal carbonisation.

[0003] In this method, biomass is converted in a laboratory auto-clave at 10 bar and 180° C. within half a day into a carbon-like material or its preliminary steps and water. The use of humid biomass for energy recovery through the production of a fuel which is as consistent as possible is aimed for a long time but has been limited in its use up to now due to the lacking efficiency. Carbon dioxide emissions by combustion of fossil energy carriers are essentially seen to be responsible for the climate change.

[0004] In DE 19723510 for example, a device for the treatment of biogenous residues was presented which comprises a cylindrical reactor in which food waste and the like is submitted to a temperature pressure hydrolysis process or thermal pressure hydrolysis. The reactor is in the form of a loop reactor having heatable casing surfaces. A flow is produced within the reactor by means of a pump for ensuring mixing of the suspension.

[0005] International application WO 2008/081407 A2 discloses a process by which sludges of biogenic origin are introduced into a co-axial loop reactor and carbonised with elevated pressure and temperature.

[0006] Patent specification US 4,579,562 discloses a process by which fragments of coal are introduced into a pressure reactor and dewatered at raised temperatures.

[0007] The international application WO 2008/095589 A1 discloses a process by which biomass is carbonised through elevated pressure and temperature. The introduction of the biomass to the reactor is achieved with controlled lock chambers.

[0008] The German patent specification DE 10 2007 012 112 B3 discloses a process and one of its means of implementation, by which biomass and water are continuously moved through a heatable pressurised container by means of a screw conveyor.

[0009] The German patent application DE 2008 012 419 U1 discloses a process and one of its means of implementation, by which biomass is fed into a heatable pressurised reactor in batches and carbonised therein.

[0010] The German utility model application DE 10 2007 056 170 A1 discloses a process for the treatment of biomass at over 160°C and 7 bar, by which the biomass is pre-treated.

[0011] Japanese patent application JP 2005-205252 A discloses a process by which a low concentration water-biomass mixture, after heating to 100-250°C in a pressurised reactor, has further biomass added to it.

Description of the Invention

[0012] It is the object of the invention to develop methods and devices, by means of which fuels, humus, carbon-containing materials as well as Maillard or Maillard-like reaction products can be manufactured economically and with high efficiency from a solid-fluid mixture, in particular, on an industrial scale.

[0013] The object is achieved according to the invention by the objects of the independent claims. Advantageous further developments of the objects of the invention result from the dependent claims.

[0014] The object is solved by advantageous method for the hydro-lysis and/or production of materials or fuels, humus, Maillard or Maillard-like reaction products from a solid-fluid mixture of water and a carbon-containing component, according to Claim 1.

[0015] A particularly advantageous embodiment of the invention is the design that non-pumpable feed materials with a solid content of 25-97% are conveyed to the reactor via the first feed strand, and pumpable heated feed materials with a solid content of 3-50% are fed into the reactor in a parallel or additive manner via the second feed strand.

[0016] The preferable ratio of mass throughput of non-pumpable to pumpable feed materials is 1:20-10:1.

[0017] A further particularly advantageous embodiment of the invention is that the non-pumpable feed materials from the first feed strand are conveyed to the reactor under a pressure above the vapor pressure of the process water. The conveying device for introducing the non-pumpable feed materials from the first feed strand to the reactor under pressure above the vapor pressure of the process water is preferably an injector, double screw extruder, or a double screw compressor.

[0018] In a particularly advantageous embodiment of the invention it is further intended that the non-pumpable feed materials from the first feed strand are fed into the reactor at a pressure below the vapor pressure of the process water and are combined with pumpable feed materials from the second feed strand.

[0019] The ideal ratio of the mass throughput of provided vs. supplied feedstocks is preferably 1:20-10:1, or 1:5-1:1.

[0020] Preferably, further feed strands will be used in the process.

[0021] The method further comprises the common use of further devices such as storage containers, comminution apparatuses, mixing vessels, dosing devices, incubation vessels, conveying devices, process water vessels, tube lines, heat exchangers or reactors.

[0022] In a further advantageous embodiment of the invention it is intended that the pump for conveying solid-fluid mixtures in the second feed strand is designed for sold contents of at least 5-10 or 10-25%.

[0023] The pump for conveying solid-fluid mixtures in the second feed strand is preferably an eccentric spiral pump, a spiral displacement pump, or a piston pump.

[0024] An advantageous embodiment of the invention is that the solid-fluid mixture to be heated flows through a heat exchanger and is thereby guided through at least 60% of essentially vertical tube parts.

[0025] The solid-fluid mixture has a preferable solid content of between 3 and 35 or between 35 and 60% and/or is guided to the heat exchanger by a pump. The pump for conveying the solid-fluid mixture and/or a counterpressure pump can for example be designed for solid contents of at least 5-10 or 10-25% and/or be an eccentric spiral pump, a spiral displacement pump, or a piston pump.

[0026] The object is further alternatively solved by an apparatus for treating a solid-fluid mixture of water and a carbon-containing component at a temperature above 100° C. and a pressure above 5 bar, according to Claim 7.

[0027] In an advantageous embodiment of these devices, it is provided that the pump is an eccentric spiral pump or a piston pump. The pump is thereby preferably designed for pressures of 10-130 bar.

[0028] A further advantageous embodiment of the apparatuses is that the heat exchanger consists of at least 60% of vertical tube parts.

[0029] The heat exchanger can further be designed for the processing of solid-fluid mixtures with a solid content of 3-50%, essentially consisting of biomass including lignocellulose and/or starch-containing material.

[0030] The preferable temperature range for the heat exchanger is 60-300°C, at least one module or unit of the heat exchanger being for temperatures of 200-300°C, and/or pressures of 10-120 bar, and at least one module of a unit of the heat exchanger for pressures of 60-120 bar. In particular, the heat exchanger or at least one module or unit is designed for temperatures of up to 250°C.

[0031] In a further advantageous embodiment of the apparatuses, it is intended that media-contacted tubes of the heat exchanger consist of heat and corrosion-resistant and water-repellent material, for example of coated metal, particular noble metals, ceramic materials or enamel. Media-contacting tubes of the heat exchanger preferably consist of a corrosion-resistant material and/or of stainless steel such as austenitic steel or steel with increasing chromium and molybdenum contents of groups 6, 7 and 8, or of duplex steel, or of copper nickel alloy, high molybdenum-containing nickel ally or titanium.

[0032] In a further advantageous embodiment of the apparatuses, the heat exchanger is a tube reactor with a tempering system, a double tube heat exchanger, a tube bundle or a plate heat exchanger or a combination thereof.

[0033] The heat exchanger consists ideally of several similar units and/or has a modular construction, wherein the similar units of the heat exchanger are arranged in a spatial vicinity to each other.

[0034] In a further advantageous embodiment of the apparatuses, a tempering system of a tube reactor consists of a double wall, wherein the intermediate space of the double wall of the tube reactor is flown through by a heat energy carrier medium. The heat energy carrier medium is preferably a thermal oil, water vapor or process water, where the heat exchanger can be designed for different heat energy carrier media and/or for a target temperature of the heat energy carrier medium of 60 and 350° C. The heat exchanger preferably consists of different modules, units or sections.

[0035] An advantageous embodiment of the device is that the hydrolysis apparatus includes a counter-pressure pump.

[0036] In a further advantageous embodiment of the invention it is provided that the pump for conveying solid-fluid mixtures and/or the counter pressure pump is/are an eccentric spiral pump, a spiral displacement pump or a piston pump.

[0037] In a further advantageous embodiment of the invention it is intended that the pump and/or counter-pressure pump is/are designed at least for pressures of 10-130 bar.

[0038] The heat exchanger for passage of solid-fluid mixtures can consist of at least 60% of vertical tube parts and/or be designed for a solid content of 3-50%, wherein the solid content can essentially consist of biomass including lignocellulose and/or starch-containing material.

[0039] A further advantageous embodiment of the invention is that the heat exchanger is designed for temperatures of 60-300°C or at least one module or a unit is designed for temperatures of 200-300°C.

[0040] The heat exchanger or at least one module or a unit of the heat exchanger is preferably designed for pressures of 10-120 bar and in an advantageous embodiment of the invention for pressures of 60-120 bar, and/or for temperatures up to 250° C.

[0041] An advantageous embodiment of the invention is that the media-contacting tubes of the heat exchanger consist of heat- and corrosion-resistant and water-repellant material, for example of coated metal, and in an advantageous embodiment of the invention noble metal, ceramic materials or enamel. The media-contacting tubes of the heat exchanger preferably consist of a corrosion-resistant material such as stainless steel including austenitic steels or steels with increasing chromium and molybdenum contents of the groups 6, 7 and 8 or also diplex steels, copper nickel alloys, high molybdenum-containing nickel alloys, as e.g. 2.4610, or titanium.

[0042] In a further advantageous embodiment of the invention it is provided that the heat exchanger is a tube reactor with a tempering system, a double tube heat exchanger, tube bundle or plate heat exchanger or a combination thereof.

[0043] The heat exchanger preferably consists of several similar units or has a modular construction, wherein the similar units of the heat exchanger are preferably connected in series and/or the modular units of the heat exchanger are arranged in a spatial vicinity to each other.

[0044] In a further advantageous embodiment of the apparatuses, a tempering system of a tube reactor consists of a double wall, wherein the intermediate space of the double wall of the tube reactor is flown through by a heat energy carrier medium. The heat energy carrier medium is preferably a thermal oil, water vapor or process water, where the heat exchanger can be designed for different heat energy carrier media.

[0045] In a further advantageous embodiment of the invention it is provided that the heat exchanger is designed for a target temperature of the heat carrier medium of 60-350°C.

[0046] The heat exchanger can also consist of different modules, units or sections.

[0047] In a further advantageous embodiment is the intention that the heat exchanger is comprised of several similar units and/or a modular composition, where the similar units of the heat exchanger can be connected in series. Preferably, the modular units are arranged close to each-other.

[0048] The tempering system of a tube reactor consists of a double wall, wherein the intermediate space of the double wall of the tube reactor can be flown through by a heat energy carrier medium. The heat energy carrier medium is preferably a thermal oil, water vapor or process water, where various heat carrying media can be combined. The goal temperature of the heat carrying medium that will flow through the heat exchanger lies ideally between 60 and 350°C.

[0049] In a further preferable embodiment of the method, the heat exchanger consists of various modules, units, or sections. The temperature in a first section or module of the heat exchangers lies for example between 60 and 100°C or 80 and 120°C; in a second section or module between 100 and 140°C or between 120 and 160°C; in a third section between 140 and 180 or between 160 and 200°C; in a fourth section between 180 and 220, between 200 and 240, or between 240 and 350°C. In this regard the units, modules, or sections of the heat exchanger can be connected in series such that the temperature of the solid-fluid mixture, after reaching a highest or peak temperature of, for example, 220 - 260°C, will be brought back to a lower inlet or outlet temperature. A further advantageous embodiment of the invention is the design that the heat exchanger will be equipped with a holding path, through which temperature can be kept at a level of, for example, +/- 2-8°C.

[0050] Preferably, the reaction mixture is guided into at least one reactor equipped with a stirring or mixing system after passing through the heat exchanger for mixing or swirling, or into a reactor whose height is at least double of its diameter.

[0051] In a further advantageous embodiment of the invention it is further provided that the components consist of feed materials, water or catalysts.

[0052] During the residence time of a batch within the reactor, preferably components, reaction products, process water, or catalysts are withdrawn, whereby the time frame in which the components, reaction products, process water, or catalysts are to be withdrawn comprises preferably at least a hundredth of the residence time. During the residence time of a batch within the reactor, components, process water, or catalysts can also be supplied for at least a hundredth of the residence time. In this way supplied process water is treated, whereby the treatment of the supplied process water can include at least a solid-fluid separation or another water processing activity.

[0053] In a further advantageous embodiment of the invention it is provided that the method takes place in the absence of oxygen.

[0054] An advantageous embodiment of the process is the design that, upon a build-up of process water, to remove it either directly from the running process or from an isolated reservoir that has been set aside as a pressurised container for untreated process water.

[0055] A further advantageous embodiment of the process is that, after the evaporation of the process water, the water vapor is used in other parts of the process, for example for heating feed material before its being fed into a heat exchanger, for heating thermal oil in a heat exchange process, and/or for operating a device for drying reaction products such as an air vortex mill.

[0056] The process water can, for example, be obtained at a temperature of 1-50°C above the temperature for the particular application. Preferably still heated process water would be used with a temperature of 25-50, 50-70, or 70-99°C.

[0057] In an advantageous embodiment, the device can also comprise an isolated and designed as a pressure vessel reservoir for untreated process water.

[0058] In an advantageous embodiment of the method, it is designed that the treatment is carried out continuously and takes at least 1 hour (1h), and/or comprises the processing of biomass and/or working up to the reaction, intermediate, by-products, and/or end products.

[0059] The temperature is preferably adjusted to above 160° C., preferably between 160 and 300° C. or between 185 and 225° C., and/or is controlled automatically.

[0060] The pressure is preferably adjusted to at least 7 bar, particularly preferably between 10 and 34 bar, in particular between 10 and 17 bar, 18 and 26 bar or 27 and 34 bar.

[0061] The treatment duration can for example be at least 2 hours, preferably 3-60 hours, more preferably 5-30 hours or 31-60 hours, in particular 6-12 hours or 13-24 hours, wherein the treatment duration is preferably chosen in dependence on the type of biomass and/or the desired reaction product.

[0062] In an advantageous embodiment of the method it is further provided that the biomass is pre-treated, preferably by dewatering, comminution, pre-incubation with additives, mixing, and/or pre-heating. The biomass is preferably incubated at acidic pH prior to treatment. The pH value can therefore lie for example under 6, preferably under 5, more preferably under 4, particularly preferably under 3, especially under 2.

[0063] In an advantageous embodiment of the method, it is further provided that the biomass is comminuted prior to, during and/or after the treatment, preferably chaffed and/or milled. The particle size of the comminuted biomass is thereby below 10 cm, below 1 cm or preferably below 2 mm.

[0064] In a further advantageous embodiment of the method, it is provided that at least one catalyst is added to the biomass prior to or during the treatment. The catalyst can be composed of several components, which together form a catalyst mixture. The catalyst is preferably an inorganic acid, preferably sulphuric acid and/or a mono, di- or tricarbonic acid, preferably tartaric acid or citric acid. The acid used as catalyst can simultaneously also be used for adjusting the pH value for the incubation step. The catalyst can comprise one or several metals and/or metal compounds, wherein the metal, metals and/or metal compounds at least one transition metal of the secondary groups Ia, IIa, IVa, Va, VIa, VIIa and VIIIa of the periodic table, preferably nickel, cobalt, iron, copper, chromium, tungsten, molybdenum, or titanium, particularly iron. The catalyst preferably comprises at least one biocatalyst, preferably enzymes, micro-organisms, plant cells, animal cells, and/or cell extracts.

[0065] In an advantageous embodiment of the method, it is further provided that the biomass is mixed prior to and/or during the treatment, preferably by stirring, mixing, suspending and/or swirling, wherein one or several mixing devices, preferably a liquid jet mixer, pump or nozzle can be used for mixing.

[0066] In a further advantageous embodiment of the method it is provided that the reaction products are dried with a drier after the treatment, preferably a convection or contact drier, with a flow and/or belt, and/or a fluidised bed drier.

[0067] Process water accumulated during the course of the method is preferably removed through at least one apparatus for solid-fluid separation and/or cleaned and fed back to the reaction mixture. The apparatus for the solid-fluid separation can thereby be at least one apparatus for the micro-, ultra-, nanofiltration and for the reverse osmosis method or a combination of different above-mention apparatuses, preferably with ceramic filter elements and in a more preferably rotation disk and/or a centrifugal membrane filter.

[0068] In an advantageous embodiment of the method, it is further provided that accumulated wastewater is mechanically, chemically and/or biologically purified. Preferably, accumulated exhaust air from treatment, processing, and/or reconditioning is mechanically, chemically, and/or biologically purified.

[0069] In a further advantageous embodiment of the method it is provided that the reaction, intermediate, secondary and/or end products comprise fuels from peat to lignite to black coal-like fuels, humus, carbon-containing materials such as insulating materials, nano-sponges, nano-pellets, nano-fibres, nano-cables, activated or sorption coal, charcoal substitute material, highly compacted carbon products and materials, and more particularly feed materials for graphite and graphite-containing or -like products and carbon fibres and feed materials for composite and fibre composite materials.

Description of Exemplary Preferred Embodiments of the Invention

[0070] An exemplary method according to the invention provides that the carbon-containing solid-fluid mixture and/or the feed materials are additionally processed prior to and/or during the treatment, and/or the reaction, intermediate secondary and/or end products are conditioned or processed. By virtue of this purposeful preparation or pre-treatment of the solid-fluid mixture and the further processing of the solid liquid mixture during the treatment or the reaction process and/or the reprocessing of the reaction, intermediate, secondary and/or end products, the yield of fuel and material can be significantly increased in a cost-effective manner.

[0071] With the methods and apparatuses according to the invention for the utilisation of biomass for the production of fuels, the proportion of carbon, which is lost during the conversion process, is substantially smaller than with other methods. Little or no carbon is lost with proper implementation. The carbon loss is over 30% with alcoholic fermentation processes, about 50% with the conversion into biogas, about 70% for a wood carbonisation process, and over 90% for a composting process. Thereby, carbon is released as carbon dioxide or also as methane, which are each regarded as greenhouse gases and being harmful to the climate. This is not the case or only to a very limited extent in the method according to the invention.

[0072] The method according to the invention has a high degree of efficiency. By contrast, alcoholic fermentation only has an estimated effective efficiency of three to five percent compared to the original energy stored in the plants. During the method in accordance with the application, no or only very little CO2 is released. During the conversion of biomass into biogas, about half of the carbon is again released as CO2. Moreover, only a few substrates are suitable for the economical operation of a biogas plant.

[0073] In contrast to methods known the heat released in the method according to the application need not remain largely unused. One of the main challenges for the energetic utilisation of biomass with high moisture content. In the method of the embodiment however, the presence of water is a prerequisite for the chemical conversion process. Previous methods applied to an industrial scale for the conversion of biomass into energy are however limited in their application by a lack of efficiency, lower energetic usability and cost-efficiency.

[0074] When treating solid-fluid mixtures such as biomass for example at high temperatures and high pressures, the reactors in which the treatment takes place can have special characteristics. Thus, the inner surface of the reactor can be corrosion-resistant or provided with an appropriate coating due to the extreme conditions. Moreover, a device for mixing of the solid-fluid mixture can be present.

[0075] In a further embodiment, the method is carried out semi-continuously or continuously. This means that the treatment of the solid-fluid mixture, in particular during the reaction process, is not carried out discontinuously that is to say in a batch process. Rather, temperature and pressure conditions are kept largely in the operating range for optimum reaction space utilization and to minimize the residence times. At the same time, feed-stock and catalysts can be delayed to be introduced during the running process; process water and unconverted feed stock as well as other added media can be removed to be recycled as needed, such as impurities; reaction products, intermediate products, by-products, and/or end products can be withdrawn. Parallel to this, further process steps such as the reconditioning and/or purification of process water, wastewater, exhaust air, reaction products, intermediate products, by-products, and/or end products can be carried out continuously or in intervals. In further embodiments it is designed that the temperature is set at over 160°C, preferably between 160 and 300°C, particularly preferably between 185 and 225°C, and/or that the temperature is automatically controlled. In a further embodiment, it is designed that the pressure is set at least 7 bar, or between 10 and 34 bar, or between 10 and 17 bar, 17 and 26 bar, or 26 and 34 bar. In a further embodiment, it is designed that the treatment duration is at least 30-60 minutes, 1-3, 3-6 or 6-24 hours, in some cases also 24-60 hours. In a further embodiment it is provided that the duration of treatment is selected depending on the nature of the feed materials and/or the solid-fluid mixture and/or the desired reaction product.

[0076] In a further advantageous embodiment of the invention, it is provided that accumulated wastewater is cleaned mechanically, chemically and/or biologically.

[0077] For example, it is also provided that in the treatment, processing and/or processing accumulating exhaust air is mechanically, chemically and/or purified biologically.

[0078] In a further embodiment of the object of the application, it is provided that the solid-fluid mixture consists at least partially of bio-mass. The principle of the hydrothermal carbonisation is thereby used by the supply of pressure and heat, so as to initially depolymerise and hydrolyse wet biomass while releasing heat energy in the efficient and highly economic method according to the application. The polymerisation of the resulting monomers leads to the formation of carbon-containing reaction products within a few hours. Desired reaction products are produced in dependence on the reaction conditions. For example, after a shorter reaction time, among others, first humus and in the further course of reaction fuels with increasing carbon content, which are suitable for energy. [0084] The application also provides the production of various reaction, intermediate, by- and/or end products, including the production of fuels from peat, and lignite to black coal-like fuels, carbon-containing materials such as insulating materials, nano-sponges, pellets, fibres, cables, active or sorption carbon, charcoal substitute, high-density carbon products and materials, and in particular also feed materials for graphite and graphite-containing or similar products and carbon fibres and feed materials for composite and fibre composites.

[0079] In an exemplary embodiment it is provided that the reactor is a cascade, tube, cycle reactor, loop and/or a stirring reactor and/or preferably a membrane and/or fluidised bed reactor. Preferably, at least one reactor or a combination of different reactors has at least one characteristic and preferably combinations of characteristics of a cascade, tube, cycle reactor, preferably a loop or a stirring reactor, or more preferably a membrane or a fluidised bed reactor. Particularly preferably, at least one reactor comprises at least one membrane part and/or at least a device for the generation of a circulating fluidised bed layer.

[0080] In a further exemplary embodiment of the invention it is provided that the device for treating the biomass comprises at least one reactor for receiving the biomass and at least one device for processing of the biomass and/or conditioning of the reaction products and/or by-products. In a further embodiment it is provided that the reactor is a tubular reactor, cycle reactor, and particularly advantageously a loop reactor or stirring reactor and/or preferably a membrane and/or fluidised bed reactor. At least one reactor preferably comprises at least one membrane part and/or at least one device for the producing a circulating fluidised bed layer. At the same time, the reactor is designed for temperatures of at least 100°C, and at least a pressure of above 5 bar.

[0081] Several reactors for receiving and treating the biomass can be provided to increase the capacity or the throughput of the system according to the application. These can be connected in series.

[0082] The material and/or fuel is produced from biomass and is in comparison to the biomass by 1-300% higher carbon content based on the percentage by mass of the elements (dry matter). The material and/or fuel include fuels from peat, to lignite to black coal-like fuels, and carbon-containing materials such as insulating materials, nano sponges, pellets, fibres, cables, pure, ultra-pure and ultra-carbon, or active or sorption carbonlike materials, charcoal substitute, high-density carbon products and materials and in particular also feed materials for graphite and graphite-containing or similar products and carbon fibres and feed materials for composite or fibre composite materials. The material and/or fuel can be compared to the biomass by 10-300%, also 50-300%, or also 100-300% and especially 200-300% increased carbon content based on the percentage by mass of the elements (dry matter). The material and/or fuel can be alternatively compared to the biomass by 5-200%, also 10-150%, also 10-120%, and especially 50-100%, increased carbon content based on the percentage by mass of the elements (dry matter) respectively.

[0083] The material and/or fuel has a carbon content compared to the feed material of 50-90%, also from 66-80%, and also of over 98%, each based on the percentage by mass of the elements (dry matter). In a further embodiment, the hydrogen content of the material and/or fuel compared to biomass is reduced by 1-300%, even 5-200%, and also by 20-100% each based on the percentage mass fraction of the elements (dry matter). In a further embodiment, the oxygen content of the material and/or fuel compared to the feed material is reduced by 1-300%, even by 5-200% and also by 15-100% in each case based on the percentage mass of the elements (dry matter).

[0084] In a further embodiment the nitrogen content of the material and/or fuel compared to the feed material is reduced by 1-300%, preferably 5-200% or more preferably 15-100%, respectively based on the percentage mass fraction of the elements (dry matter). The material and/or fuel according to the application can comprise at least or more than 65% of the original fuel value of the feed materials and in particular the biomass based on the dry matter. The material and/or fuel can have, due to its composition and structure compared to the biomass or alternative fossil or biomass fuels, significantly more advantageous and environmentally friendly combustion characteristics, for example due to reduced ash parts, lower chlorine, nitrate, sulphur and heavy metal content, and lower emissions of dust, particulate matter, fine dust and gaseous toxic substances including nitrogen and sulphur oxides.

[0085] The material and/or fuel can further also comprise a higher reactivity and a lower autoignition temperature compared to the biomass or alternative solid fossil or biomass fuels. If the material and/or fuel is porous, it can be comminuted with a lower energy expenditure than solid fossil fuels with a comparable calorific value or carbon content. A large surface results with a small particle size of the material and/or fuel, in particular a particle size of about 2 nanometres to 50 micrometres, even less than one micrometre, and also less than 200 nanometres. The material and/or fuel can then be dried well due to the small particle size and its large surface.

[0086] The material and/or fuel can contain Maillard or Maillard-like reaction products. In one embodiment, the material and/or fuel of biomass is produced according to a method which comprises at least the following steps: treatment of the biomass at a temperature of above 100° C. and a pressure of above 5 bar for a treatment duration of at least one hour and treatment of the biomass and/or conditioning of the reaction, intermediate, by- and/or end-products. The temperature can be adjusted to over 160°C, also between 160 and 300°C, and also between 185 and 225°C. The pressure can be adjusted to at least 7 bar, also between 10 and 34 bar, and also between 10 and 17 bar, 18 and 26 bar or 27 and 34 bar. The treatment duration may be at least 2 hours, preferably 3-60 hours, even 5-30 hours or 31-60 hours, especially 6-12 hours or 13-24 hours. After treatment of the biomass, the reaction products are dried with a drier, also with a convection or contact drier, with a flow and/or belt, and/or with a fluidised bed drier to a desired residual moisture content of 6-25%, even 10-20%, or even 12-15%.

[0087] The reaction, intermediate, by- and end-products of the method described above include fuels from peat, to lignite to black coal-like fuels, and carbon-containing materials such as insulating materials, nano sponges, pellets, fibres, cables, active or sorption coal, charcoal substitute, high-density carbon products and materials and in particular also feed materials for graphite and graphite-containing or -like products and carbon fibres and feed materials for composite or fibre composites.

[0088] Biomass comprises, contrary to fossil fuels, renewable raw materials which are available in the long term as domestic energy carriers, as well as all liquid and solid organic substances and products of biological and biochemical processes and their conversion products which have a sufficiently high carbon content for this method and which can also otherwise be processed in their composition and property to economically usable reaction, intermediate, bi- and end-products by the method according to the application including fuels. The feed materials are for example among carbohydrates, sugar and starches, agricultural and forestry products, also specially cultivated energy plants (fast growing tree species, reeds, whole grain plants and similar), soy, sugar cane and grain straw, as well as biogenous residual, waste and by-products, plants and plant residues of other origin (roadside greenery, landscape preservation and similar), agricultural waste including straw, sugar cane leaves, waste grain, unsalable parts of agricultural products as for example potatoes or sugar beets, decomposed silage and other leftover food, grass clippings, grain straw, beet leaves, sugar cane leaves, carbonous residues and waste including biowaste, high-calorific fractions of domestic and industrial waste (residual waste), sewage sludge, different types and classes of wood including forest wood, timber, pallets, old furniture, sawdust, residues and waste from the food industry including kitchen and food waste, waste vegetables, waste grease and paper and pulp, textiles in particular natural fibres and natural polymers and animal excrements including manure, horse manure and poultry droppings. Carcasses and in particular animal carcasses can also be counted as biomass.

[0089] As treatment of the feed material and/or of the solid-fluid mixture in the sense of the application are to be understood all influences or effects on the solid-fluid mixture which serve for the conversion of the solid-fluid mixture into the reaction products, in particular the supply of energy for starting and maintaining the reaction, including the treatment of the solid-fluid mixture at a temperature of over 100°C. and a pressure of over 5 bar. Processing of the biomass and/or of the solid-fluid mixture in the sense of the application is processing of the feed material, reaction and/or intermediate products in different steps before and after the chemical reaction process. Processing comprises all steps, processes and effects on the reaction partners, including the pre-treatment and/or after-treatment.

[0090] As pre-treatment all effects are understood which act on the solid-fluid mixture until of the conversion reaction until the end of the filling process of the reaction space and the start of the supply of energy for initiating reaction of conversion.

[0091] In particular, a preheating of the feed material and a comminution with predominant, i.e., more than two thirds of the components of the reaction mixture, particle size of less than 10 mm within or outside the reaction space is regarded as pre-treatment.

[0092] Solid-liquid mixtures within the meaning of the application are all suspensions, dispersions and other disperse systems, including liquid-containing solids, in particular biomass. The method finds particular application for those solid-fluid mixtures which, during the reaction, lead, physically or chemically, to an increase in the content of the liquid phase or to solvents and / or to the physical or chemical modification of the solid, which enables an improved solid-liquid separation or altered ratio with higher solids content. Starting materials in this context are liquid-containing or non-liquid-containing solids which are used to prepare the solid-liquid mixture.

[0093] Reconditioning or conditioning of the reaction products and/or secondary products in the sense of the application comprises all influences or effects on the secondary and/or end products of the conversion reaction, by means of which these are brought into the desired or necessary form.

[0094] The semi-continuous or continuous method in the sense of the application is to be understood as the production of reaction, intermediate, by- and end products on a pilot scale and/or industrial scale, in which at least one criterion, or two or even more of the criteria listed below are fulfilled:

1. The temperature, in particular in at least one pressure vessel, reactor or plant component, is continuously above 40-90 degrees Celsius over at least two reaction cycles, preferably from 60-70 degrees Celsius and / or above the boiling temperatures of the process water at a bar absolute pressure, so that a longer immediate and inconsequential manual contact with the container wall, which is directly in contact with the reaction mixture of more than one minute is only possible with auxiliary means, insulating substances or additional devices.
2. The pressure, in particular in at least one pressure vessel, reactor or plant component, is continuously across at least two reaction cycles above one bar absolute pressure. At least two containers, of which at least one reactor, are connected to one another in such a way that transport, pressure equalization or the storage of compressed media can be realised.
3. The processing of the feed materials, solid-fluid mixtures, reaction, by-products, intermediates and / or end products or other reactants is carried out in more than one container within the plant.
4. The total volume of the containers in which this processing takes place, which are at the same time fixed components of the plants, amounts to at least 500 litres, whereby at least one of these containers can be moved not only manually but only with additional aids.
5. A pre-treated carbonaceous solid-fluid mixture and / or different types of feed materials, biomass or carbon compounds, in particular of different nature and consistency, are used during a reaction cycle.
6. Different feed materials of the solid-fluid mixtures, reaction, by-products, intermediates and / or end products and / or other reactants, including catalysts and / or propellant or tempering media such as water, in particular process water and / or gas such as process / synthesis gas, are supplied from a reaction cycle simultaneously, time-shifted, continuously or discontinuously or withdrawn from the reaction mixture. The process under 6. take place while the temperature of the pressure vessel, reactor or other plant components is above 60-70 degrees

Celsius or above the boiling point of the process water at a bar absolute pressure or during the pressure of at least one system component is above one bar absolute pressure.

7. The reaction mixture is treated within a coherent process, in particular within a plant.

8. Before and / or during the reaction cycle, the feed materials or the reaction mixture are set in motion by introduction of kinetic energy, in particular by at least one stirring or mixing system or a combination of stirring or mixing systems of any kind, preferably with the cooperation of at least one non-mechanical stirring or mixing system, which when using a single system, this has no magnetic coupling with only one shaft and at the same time is not operated electrically.

9. Before and / or during the cycle, thermal energy is supplied to and / or removed from the feed materials or the reaction mixture, in particular using at least one tempering system or a combination of different systems or devices, wherein when using a single system this is preferably not a commercial oven and / or does not have a wall-mounted heat transfer by a casing vessel that can be separated with a few hand grips, which is operated electrically.

10. The continuous method is particularly characterised by the characteristics contained in the description and characteristic combinations of the apparatuses and devices used for the conversion of the continuous methods. Further criteria for a continuous method can be derived from the characteristics contained therein, where carbon-containing feed materials are continually fed to a first reactor and the reaction mixture is guided from one reactor to the next in batches and reaction products are continuously discharged from a last reactor.

[0095] A container is to be understood to be an object open or closed at the top having a cavity in its interior, which particularly serves for the purpose of separating its content from its environment. A container in which the conversion reaction, i.e. the treatment of the solid-fluid mixture, and/or the processing of the solid-fluid mixture is carried out, for example a pressure vessel or a reactor is formed by a reaction space or pressure container space closed to the outside.

[0096] A reactor is described particularly as a container in which decisive reaction steps take place. As decisive reaction steps are particularly understood the steps which run to a great extent for example in a temperature and pressure region, which has to be present on average to be able to convert at least 10-30%

of the feed material into one of the mentioned reaction products, intermediate products, by-products, or end products.

[0097] Reaction spaces or pressure container spaces are defined by the existence of spatial regions also within only one reaction or pressure container space, in which reaction conditions which are measurably deviant from one another are present. A deviant reaction condition thereby comes about through a structural, mechanical, flow and / or phase-related, chemical, electrical, or electrochemical or other kind of effect. The device used for this purpose is usually via an electrically operated stirring or mixing system with a single shaft with magnetic coupling and a wall heat transfer of a pressure-loaded smooth inside of the outer reactor wall by a few handles separable heated jacket vessel, which is electrically operated , an autoclave for laboratory use.

[0098] The reaction cycle, cycle or reaction is to be understood as the duration of a single conversion reaction which starts with the introduction of the feed products into the reaction space and the supply of energy which serves for the initiation of the conversion reaction. One cycle lasts from the start of the reaction process to the existence of the desired reaction product in the reaction mixture without after-treatment or conditioning, or until the completion of the reaction process.

[0099] Stirring or mixing systems include apparatuses which transfer the energy to the reaction mixture mechanically or by means of ultrasound, depending on flow, thermal conditions or depending on construction and thereby cause a movement of the reactor content by stirring or agitation. This also includes the movement of the reaction mixture through devices such as pumps, liquid stream mixers, nozzles and mechanical and thermal mixers or the flow of the reaction mixture along pressure gradients.

[0100] A plant consists of at least two devices or devices for carrying out the method according to application. At least two containers or vessels, at least one of which is a reactor, can be connected in such a manner that a pressure equalisation or the storage of compressed media can be realised. An integral or essential component of the plant is a device or a container where in the case of a failure of this component, the efficiency of the method is restricted in particular in view of its cost-effectiveness by at least two or five percent, and especially preferred to be by at least ten percent.

[0101] A coherent process is present if multiple devices or devices of a plant are used together. More than 200 kilograms of feed material can be processed in such a plant per week in relation to the dry matter. A plant can then be considered to be in use together when devices or devices are connected to one another or by line connections or spatially by methods which allow an exchange of starting, intermediate, secondary and reaction products and also other reaction participants or the common use of the same participants within a radius of 50 km.

[0102] The start or the initiation of the reaction or of the reaction process is characterised by achieving at least one target parameter of the reaction procedure, including pressure or temperature, at which point the hydrothermal carbonisation conversion reaction can take place over a period of at least one hour. The end of the reaction process is characterised by the continual absence of at least one of the target parameters of the reaction procedure prior to the emptying of the reaction space. Reaction, intermediate, or secondary products or partners in the sense of the application are all solid, liquid and gaseous substances which are or have been found under operational conditions (pressure higher than 5 bar, temperature higher than 100°C) independently of their length of stay in the reaction space.

[0103] Solid-fluid-mixtures in the sense of the application are all suspensions, dispersions and other disperse systems, including liquid-containing solids, particularly biomass. The device according to the application is in particular used for those solid-fluid mixtures which lead, during the reaction process, to an increase of the content of the liquid phase or more specifically to solvent, and/or to the physical or chemical change of the solid which enable an improved solid-fluid separation or changed ratios with higher solid parts.

[0104] Suspensions and dispersions are both heterogeneous solid-fluid mixtures. A heterogeneous (immiscible) substance mixture of a liquid and a solid is to be understood as a suspension. A suspension has at least one solid phase and at least one liquid phase. Disperse systems, that is binary mixtures of small particles and a continuous dispersion medium, include colloidal dispersions, micelles, vesicles, emulsions, gels, and aerosols, for example paints, emulsions or foams.

[0105] Maillard-like reaction products in the sense of the application are to be understood as compounds which are intermediate, secondary, end products or reaction partners of Maillard reaction products and which can possess similar chemical, physical or biological properties. The Advanced Glycation End-products (AGE) which are generated by rearrangement of the primary Amadori products are among these compounds and which further react to the end products of the Maillard reaction, the Advanced Glycation End-products (AGE). The AGEs can form cross-links with other proteins through rearrangement and polymer-isation. Due to the development path, there are numerous different and complex forms of AGEs, of which NE-(carboxy-methyl)lysine (CML), furosine and pentosidine have been examined most intensely up to now.

[0106] Polytetrafluoroethylene (PTFE)-like substances are understood as substances and compounds of similar, related, or non-related classes that possess at least one or several characteristics of polytetrafluoroethylene, for example reaction inertness, very low friction coefficient, very low refractive index, high heat resistance, low adhesion durability of surface contaminations, or a smooth surface.

[0107] Fuels are substances which serve for the energy production and which are converted into energy thermally, chemically, electrically or other methods. Materials are substances which are processed into a product by further processing, treatment or conditioning, or which go into an end product as work objects.

[0108] The characteristics of the reaction product such as degree of purity, form, structure, density, mechanical resistance or strength, particle size, surface structure, composition, combustion characteristics, fuel value and energy content depend on the methods or reaction conditions; that is, the parameters which are responsible for the control of the method; that is, for the process procedure.

[0109] The feed material and the reaction, intermediate, secondary, and/or end products are processed in different steps before and after the chemical conversion process. The processing steps aim for substance conversion on an industrial or pilot scale. Thus, processing is to be understood as more than a manual disassembly or a manual comminution with a pair of scissors. The processing of the biomass, and/or the reconditioning of the reaction products and/or the secondary products in the method according to the application, proceeds via an electrically-operated stirring or mixing system with a single shaft with magnetic coupling as well as a wall-mediated heat transfer of the pressurised smooth inner side of the outer reactor wall, using an electrically-heated casing container which can be separated with a few hand grips. It also comprises the criteria mentioned for the stirring or mixing system and/or tempering system for the semi-continuous or continuous method mentioned under point 9 and 10.

[0110] The biomass can usually be comminuted before storage, and particularly before the actual conversion process, in particular before and/or after the filling into the reaction space. The comminution is achieved particularly mechanically, preferably through shredding. A device for milling, for example a grinder or a wet mill, is usually used for grinding. Different chaffing, mill, and/or wet mill types are used depending on the feed material and the desired particle size. The particle size influences the reaction progress. Thus, the smaller the particle size, the larger is the surface of the feed material. The larger the surface of the reaction partners, the faster the chemical conversion. The particle size of the comminuted biomass can thus be under 10cm, also under 1cm, and also under 2mm.

[0111] The energy, time and material effort during the comminution process is thereby dependent on the process procedure and in particular on the configuration of the feed material, particle size and incubation period.

[0112] Part of the pre-treatment process is incubation in an acid environment or medium with a pH-value which is below 6, also below 5, and also below 4, particularly below 3 or also under 2, is part of the pre-treatment. The necessary duration of this step decreases with increasing comminution and with decreasing pH-value. The incubation at an acidic pH-value can for example take place after comminution. The incubation takes place in an insulated incubation vessel equipped with a double wall or another tempering system. The tempering system is essentially used via process heat or waste heat from the production process or another process, or with partially purified and heated process water. The incubation period is at least 10-60 minutes, 1-10 hours, or 10-60 hours. A pre-incubation can considerably reduce the reaction time in dependence on the feed materials and other pre-treatment steps. The savings in time are over 3-10%, 10-20% or more under ideal conditions.

[0113] As water is produced chemically during the conversion reaction and is split from the feed materials, the water volume increases over the course of the process. By removing process water, the necessary reaction volume required for the reaction space required for example by the following reaction containers, is reduced. In the sense of a reactor cascade, the volume of each individual reactor therefore reduces over the course of the reaction. Process water can be obtained during or after concluding the conversion reaction. The withdrawal of process water during the process takes place at a temperature of above 180°C and a pressure of over 5 bar. This makes special demands of the devices and methods for solid-fluid separation. The aforementioned process includes several sieving processes (coarse sieving, fine sieving); filtration processes and/or the centrifugal force deposition by cyclone, dynamic, static, vacuum, pressure and sterile filtration, among these especially cross-flow filtration including micro, ultra, and nano filtration; reverse osmosis methods. Preferably, devices that employ hydrocyclones, centrifuges, separation devices supported by force fields, and/or filtration methods as their underlying functional or procedural principle are used. Particularly preferred filtration methods are those which can also be used in the reaction conditions of hydrothermal carbonisation. Rotation disk filters or centrifugal membrane filters are preferred for solid-fluid separations under operational conditions.

[0114] Different methods of solid-fluid separation can be combined with one another. Each reactor following the first can be connected to device for solid-fluid separation. The solid-fluid separation takes place continuously or intermittently over a period of at least one twentieth of the dwelling time in a reactor. It can be adapted to meet requirements depending on the needs and performance of the device used. The withdrawn process water is kept in an insulated corrosion-resistant vessel or pressure vessel under air exclusion.

[0115] To enrich the process water, it is removed either directly from the running process or from a reservoir for untreated process water. The enrichment of process water is carried out on the one hand by one or several solid-fluid separation devices mentioned in this patent specification and/or on the other hand by evaporating water in, for example, an evaporator. The water vapor obtained from the evaporation process is used at another location in the process, for example for heating the feed materials prior to entry to a heat exchanger, heating of thermal oil via a heat exchanger process, or for operating a device for drying of reaction products, such as an air stream mill or another drying device mentioned at another location of this document.

[0116] At least 1-5, 5-20, or 20-70% of the water is removed to enrich the process water. For this, other methods mentioned in this patent specification will also be used, for example reverse osmosis, with the disadvantage that the temperature has to be further reduced due to temperature-sensitive membranes, however. The process water is stored in an insulated and corrosion-resistant vessel or as a process water reservoir designed as a pressure vessel, if possible, with exclusion of air.

[0117] Enriched process water is partially used for the pre-incubation, preheating of feed materials, production of a pumpable solid-fluid mixture, for addition to the reaction mixture, for coating or admixing with provided feed materials in a reactor of the plant, for return into the running process, as a heat carrier medium for further processes within or outside a plant, and/or as a fertiliser component. The process water is obtained at temperatures of 1-50°C above the temperatures for the respective uses.

[0118] For preincubation, preheating of feed materials, production of a pumpable solid-fluid mixture, or for coating of or admixing with a provided feed material in a reactor of the plant, it is advantageous to use process water or enriched process water with a temperature of 25-50, 50-70 or 70-99°C. The pH-value for these purposes is advantageously below 6 or below 4 or below 2. It is advantageous to use process water or enriched process water with a temperature of 25-50, 50-70 or 70-99°C as a heat carrier medium for further processes within or outside of a plant. Temperatures of over 100 or 200°C can however also be of advantage for these purposes, as well as for admixing with a provided feed material in a reactor of the plant for return to the running process.

[0119] The necessary pH-value is obtained on the one hand by the amount of evaporated or otherwise eliminated water, and on the other hand by the use of acid as catalysts, the boiling point of which is above the one of water. Enriched process water contains catalyst components insofar as they have a boiling point above water. Sulphuric acid has for example a boiling point of 279°C. The decomposition point of phosphoric acid is 213°C. An acidisation, that is a decreasing pH-value, is achieved by continuous evaporation of water at temperatures below the boiling point of the acids, even if it can hardly be avoided that catalyst components escape with the process water steam from the process water despite a higher boiling point. This applies similarly for metallic catalysts such as iron (II) sulphate with a melting point or a decomposition point above 400°C, iron (III) chloride with a boiling point above 120°C (sublimation) or iron (II) chloride with a boiling point of 1026°C. One or several catalyst components can be saved by enriching the process water.

[0120] The process water vapor is used at another location in the process, for example for heating feed material prior to entry into a heat exchanger, heating of thermal oil via a heat exchange process, or for operating a device for drying reaction products such as an air stream mill and/or a drying device mentioned at another location of this document. A cleaning of the process water vapor takes place depending on its application. Enriched process water can be conveyed with several pumps mentioned in this document at temperatures also above 250°C, for example by a helical displacement pump. The temperature is reduced for example via a heat exchanger at ambient pressure or prior to the feed into a device or a mixer at ambient pressure, so that the solid-fluid mixture has a temperature of 50-60 or 60-80°C.

[0121] In particular, metallic, inorganic or sand-like substances, and other impurities are separated from the biomass. Methods and processes are used in the treatment of the biomass and organic waste that are already established for example in biogas plants. A catalyst with or without the addition of water and/or in an aqueous solution can be added after pre-incubation in the acid medium, but also at an earlier or later time.

[0122] The biomass is thoroughly mixed with the catalyst or catalyst mixture. The catalyst then forms a reaction mixture with the biomass. The mixing process can alternatively take place within a reactor. Compression of the reaction mixture can take place in one or more steps outside or within a reactor. High compression is advantageous, again meaning a better usage of the reaction space. The level of compression depends on transferability into a reactor from the desired reaction product and from the process procedure. The reaction mixture can for example also be introduced into a reactor after pre-treatment. Preheating can for example occur before the introduction of reaction components into the pressure container space. All reaction partners can be preheated. All feed material, but particularly biomass, can be heated to approximately 60-90° C. The preheating takes place, for example, by adding heat energy and particularly process water at close to boiling, a preheated biomass suspension or other water at about one bar absolute pressure, or by the supply of water or process steam or other heat energy carriers. Alternatively or additionally, heat energy from heat exchange processes can be used.

[0123] The reaction time is, depending on the desired reaction product, 1-60 hours, 3-40 hours, 5-18 hours. The reaction time is considered finished and the reaction terminated when no more noteworthy enthalpy is released. A minimal pre-treatment and/or the omission of individual pre-treatment steps can increase the reaction time to over 60 hours. The reaction time is particularly dependent on the composition and characteristics of the respective feed material. The larger the surface, the smaller the particle size, the smaller the lignin or cellulose proportion and the larger the carbohydrate proportion, the faster the heat energy is released in the depolymerisation phase and the faster the stabilisation phase is reached, reducing the reaction or retention time. The shorter the conversion time of the respective feed material, the greater the delay can be, for example for introduction into an already running reaction in the reactor. A shorter reaction time is also achieved with relatively large proportions of fat and non-vegetable, non-crosslinked proteins, for example animal or bacterial proteins. The end of heat energy release during the reaction process indicates the end of the conversion process.

[0124] Temperatures of up to 300, 400, or 500°C can be achieved. However, temperatures between 185-205°C are advantageous, particularly up to 215°C, and especially up to 225°C. According to the application, a pressure is built up under exclusion of air, which is for example 7-90 bar. A pressure of 11-18 bar is advantageous, also 18-26 bar and also 26-34 bar.

[0125] The device comprises a reactor which can be adapted depending on the processes running therein, the amount and type of solids used, and/or desired reaction product. At least one of the reactors can for example be a cascade, tube, circuit, loop, membrane, fluidised bed and/or a stirring vessel or a stirring vessel reactor, or comprise individual characteristics or a combination of different characteristics of these reactors. The fluidised bed of the reactor is preferably circulating. The reactor or a combination of different reactors can be used for different treatment times and processing steps within a plant. Furthermore, due to the necessary pressures the reactor can be designed as a pressure vessel. The design of the pressure vessel form depends on the process procedure and on the mixing technique used.

[0126] In a further embodiment of the object of the invention, the reactor is equipped with a type of multi-membrane fluidised bed reactor with a circulating fluidised bed. Such a reactor combines the advantageous characteristics of different membrane and fluidised bed reactor types.

[0127] The reactor can exhibit one or more of the following characteristics: the reactor can comprise at least one pressure container and at least one device for solid-fluid separation, and is then also called a membrane reactor; the reactor can have at least one coarse and/or a fine filtration or a combination of both devices, which can also be combined into a filtration device; at least one of the pressure vessels can have a stirring and/or mixing system, which can thereby be called stirring vessel reactor; the sum of all reaction spaces of the pressure vessels or reactors can have a volume of 0.5-10,000 cubic metres, also of 5-2,000 cubic metres, and also of 50-500 cubic metres.

[0128] The sum of all containers of a plant including the reaction spaces of the pressure vessels or reactors, hoppers and storage spaces can have a volume of 0.5-1,000,000 cubic metres, also 10,000-700,000 cubic metres, and also 50,000-500,000 cubic metres. Depending on the feed material and the biomass, the water content of the biomass can be up to 95% or more of the total weight. The integration of a dewatering process which precedes the conversion reaction can be useful for this reason. Due to the high moisture content and the low packed weight of many biomasses, the transferability is limited so that the initial solids content in the reaction space can be approximately between 5 and 30%. The yield of reaction product can therefore be in the region of a single figure percentage of the total reaction space volume. As a consequence, a relatively large reaction space volume is necessary. This can be realised by connecting several pressure vessels.

[0129] By a connection of several pressure containers or reactors, for example in the sense of a cascade, and/or the combination of different reactor types, a more advantageous retention time distribution and therefore higher operational capacity can be realised through an improved control of the process progress. At the same time, the different requirements of the different reaction phases and partial steps can be accommodated. A more favourable heat exchange can for example take place in a tubular reactor, a better mixing and remixing in a stirring vessel or stirring reactor. By the breakdown of the total volume of the reactor into several pressure vessels, the ability to transport individual plant components including the pressure vessel is improved. At the same time, the realisation of a continuous or semi-continuous process is facilitated by the connection of several pressure vessels or reactors. At least one pressure vessel for the uptake of compressed process gas formed or contained in the reactors can be used and integrated into the plant. The process gas is cleaned in its own cleaning process, for example in an air cleaning plant, before it is discharged to the ambient air or fed into combustion air in its own combustion process within or outside the plant. Process gas is fed into the oxidation process as part of wet oxidation, which operates with compressed air. If heat recovery is connected with this process, there is the advantage that oxidisable components in the process gas are converted to heat energy and recovered via a heat exchange process.

[0130] The solid portion can be increased during the process by continual separation or withdrawal of single reactants such as water during the process progress. The solid content can increase from for example an original 15% to 20-30%, preferably 31-45%, or especially preferably 46-70%, depending on the reaction procedure. At the same time, the volume per reactor can decrease, more quickly convertible feed material can be added, or a higher throughput than a given reactor volume can be achieved. Furthermore, a connection of several reactors in series, which are for example separated by valves, enables a selective filling or refilling of individual pressure vessels with fresh feed material, reactants or catalysts to increase the throughput. The transfer of the reaction mixture from one pressure vessel to the next essentially takes place at operating conditions in the sense of a continuous process management.

[0131] The reactor can comprise a vertical cylindrical base structure. The diameter-height ratio is at least 1:0.5, 1:2, 1:5 or larger. The upper base can take the form of a torospherical head. The upper part, preferably the upper half or more preferably the upper two thirds, can comprise a conical form with a slowly growing diameter towards the bottom. The cone-shaped base can comprise an angle to the reactor axis of 45 degrees maximum, preferably 40 degrees or particularly preferably smaller than 35 degrees. The transition, for example from the wall to the base region, can be rounded to minimize flow disruption. The placement of the nozzle for the supply of the reaction mixture can be variable and is for example in the upper half, preferably in the upper third of the pressure vessel. The supply can take place via a valve via the outlet nozzle which is approximately in the centre of the base or the cone base. The components and the nozzles of the reactor can be connected by welding. The lid can be mounted. With a preferential use of liquid stream mixers or jet vacuum pumps and full jet nozzles, the ratio of the diameter to the height can be approximately at 1:2-1:3, but also at 1:4-1:5, and also at 1:5-1:6.

[0132] A membrane reactor is a device which allows the combination of at least one chemical reaction with a membrane process or solid-fluid separation. Both processes are thereby integrally coupled with each-other so that synergies can emerge. Both processes can be accommodated simultaneously in a single housing or plant. During the chemical reaction, at least one component of the reaction mixture is converted. Through the use of a membrane reactor, reaction, intermediate, secondary, and end products can be selectively removed from the reaction mixture, educts can be added in a controlled manner, or the contact of the educts can be intensified. Reaction, intermediate, secondary, and end products, and in particular water, are removed continually or in intervals from the reaction mixture. A distinct turnover increase can thereby be achieved.

[0133] The combination, positioning, design, and control of the respective tempering system result from the process procedure and particularly depend on the composition of the feed material. All process water systems outside and within the reactor can be used for the tempering process. This can take place on the one hand by external, that is, heat exchange processes outside the reactor, and on the other hand by the introduction of tempered process water as a dilution, tempering, suction medium or propellant for mixers, pumps and/or nozzles as aspired material for the liquid jet or jet vacuum pumps. A mixing of process and fresh water can equally serve for as optimised reactor tempering. Additionally, the process course can thereby be optimised, for example by decreasing the concentration of certain inorganic substances. Advantageously, the supply can be a tempering medium, particularly through injecting tempered water or recycled process water at temperature-critical points. The tempering is additionally controlled through the course of the procedure. In addition to the combination of feed material, pH-value, sample preparation, and catalysts, the time-delayed introduction of feed material is an essential element of temperature control, depending on its conversion characteristics. In the course of the process, the viscosity, density, amount, and other characteristics of the feed material or reaction mixture change. These changes can be attributed to chemical reactions and structural changes of the carbon-containing feed material, which can also be attributed to the depolymerisation and later to the restructuring of the feed material. From this, different requirements are made of the mixing process depending on the course of the process. A mixing and/or flow distribution which is as even and homogeneous as possible depends on the state of the process, the feed material, the solid concentrations and the requirements which are made of the reaction product.

[0134] The materials present in the process water depend on the mixture of the feed material and the process control, including the catalysts. Materials previously bound to the biomass are dissolved by procedural disintegration. Numerous elements, including chlorine, sulphur, nitrate and their salts, as well as metals, particularly heavy metals and minerals, and alkalis such as potassium or sodium and their salts, pass into the aqueous phase in a certain proportion during the chemical conversion process. One portion is again bound in the solid phase. The remaining part remains in the liquid phase. The portions of materials which go into the liquid phase also depend on the concentration difference, that is, the concentration already present in the liquid phase. With increasing concentration, saturation up to the precipitation of certain materials takes place. Inorganic materials and compounds, for example sulphate and chloride, can thus precipitate as salts and thereby influence the course of the process and reactor components unfavourably. The portion of organic carbon compounds in the liquid phase can be above 50g per litre. The Chemical Oxygen Demand (COD) value of the process water is already in the higher 5-digit region (mg O2/l) without recycling and therefore significantly exceeds legal disposal limits. The Chemical Oxygen Demand (COD) is to be generally understood as the amount of oxygen that is necessary to chemically oxidise all organic contents of a defined material amount.

[0135] A process water fraction of 10-35%, also of 35-60%, or also of 60-85% is recycled, depending on the moisture content of the feed material and the method procedure, including the solid-fluid ratio. An almost complete return of the process water, that is, a circuit closure or restriction of the process water circulation with the aim to save fresh water and to reduce the waste water volume circuit, is only possible in a limited manner. In addition to the accumulation of organic carbon compounds, an enrichment of inorganic materials such as sulphate, nitrate, calcium, chlorine, phosphorous or their compounds results. Inorganic impurity concentrations accelerate the corrosion. Lime deposits disrupt flow in the reactor and also damage mountings such as pumps, valves and nozzles, increasing the requirements of the reactor design. Sulphates can precipitate. The speed of the accumulation and saturation depends on the material composition of the feed material and the process course. The chemical conversion process usually lasts several hours. During this time, complex chemical processes connected with material changes take place which have to be considered for the optimisation of the method procedure.

[0136] Different types of biomass are supplied in intervals in the first two to three process phases. Depending on the desired reaction product, reaction products are withdrawn for example towards the end of the last two process phases. Propellant or tempering media such as a gas, water, in particular process water and/or process/synthesis gas and catalysts, are withdrawn or supplied during the running process. Reactants and in particular secondary products are removed, which disturb the course of the chemical reaction, the mixing and also the flow.

[0137] Different methods can be used for the deposition of solid materials and in particular reaction products in the reaction mixture. Solid-fluid separation serves for the separation of the liquid phase, wherein a concentration of the solids is achieved. Different sieving processes (coarse sieving, fine sieving), filtration processes, and/or deposition by centrifugal force by means of a cyclone can be combined with one another for separation of solids. To reduce the effort of a filtration or the sieving during the process, one or several filtration or sieving processes are carried out within the scope of the pre-treatment.

[0138] From these two methods, at least one coarse or one fine filtration or a combination of these two methods can take place. By means of filtration methods, particularly micro and/or ultrafiltration or a combination of both, one third to two thirds of the total organic carbon compounds can be removed from the process water. The solid-fluid separation is preferably carried out at operating conditions, and usually goes beyond the use of simple paper filter as are for example used on a laboratory scale. The choice of the methods used depends among others on chemical composition, particle size distribution, density, particle form, firmness, and solubility, and includes the use of electrical currents and loads, different densities and centrifugal forces, and different particle sizes.

[0139] The devices used include dynamic, static, vacuum, pressure, and sterile filtration, of these particularly cross-flow filtration including available micro, ultra, nanofiltration, and reverse osmosis processes. Preferably, devices that employ hydrocyclones, centrifuges, separation devices supported by force fields, and/or filtration methods as their underlying functional or procedural principle are used. The preferred filtration methods are particularly those which can be used under the reaction conditions of hydrothermal carbonisation. For solid-fluid separation, particularly at operating conditions, rotation disk filters or centrifugal membrane filters are preferred. The preferred material responsible for the formation of the pores consists of metal and in particular of ceramics. The form of the pore-forming material is preferably disk-shaped. Depending on the filtration method used and materials introduced, there is not always a proportional ratio of pore size of the filter and the solid amount in the filtrate. This particularly applies to the use of ceramic materials for the filter elements. The aqueous phase is introduced into a process water reservoir in a filtered or unfiltered manner. The characteristics of the solids to be separated, and thereby the choice of method chosen for the separation, depend on the process course and on the characteristics of the desired reaction product. The further the process has progressed and the higher the density of the reaction product, the easier it is to carry out the separation process. Separation preferably takes place near operating conditions. The amount of solids in the filtrate usually decreases proportionally to the pore size and can increase significantly by using ultrafiltration, to be over two thirds to four fifths. One or several devices for solid-fluid separation are integrated into the process for the elimination of sand and other impurities with a high density or high weight which become separable in the course of the treatment of the biomass. The use of the principle of centrifugal solid separation is particularly advantageous for cleaning process water for use as a propulsion medium, to protect pumps, mixers, and nozzles.

[0140] During the process, process water is withdrawn at one or several locations in the upper half, preferably the upper third, or especially preferably the upper quarter of the reactor for treatment. Treated process water is returned to the water circulation of the plant for recycling. At least one and preferably several process water reservoirs can be used for every individual reactor or for several combined reactors, and for other devices of the plant. Different cleaning steps precede the individual process water reservoirs. The volume of individual or a common process water reservoir is approximately 35-85% of the sum volume of all reactors. The process water reservoir is designed for the temperature and pressure load of the reactors, so that pressure reduction and heat exchange devices are not strictly necessary. Process water cleaning is integrated into the water circulation of the described plant. Different treatment or reconditioning methods are necessary depending on the use of the reconditioned process water. Different mechanical, chemical and biological methods and devices are used for this, individually or in combination: aerobic and anaerobic high-performance bio-reactors, bio-membrane reactors, and anaerobic and activated slurry methods. The above-mentioned methods and devices, integrated or connected into the process water circulation, shall decrease the content of organic compounds in the circuit water considerably; however, the degree of process water return has to be made depending on the concentration of insufficiently disintegrated organic substances and alkali metals or rather mineral materials such as calcium. So as to be able to return as high a proportion of process water as possible, a particularly effective combination of different methods and devices is used.

[0141] The device for mechanical waste water cleaning is a filter, microfilter or ultrafilter, and can be congruent with the methods for the solid-fluid separation described above. The device for solid-fluid separation, into which the filter(s) are built, is preferably a rotation disk filter and especially a centrifugal membrane filter. For the biological cleaning of the process or waste water, a device is used which best satisfies the complex requirements for cleaning or treatment. For example, a device of steel construction is preferred, for example a high-performance bioreactor in the bio-membranous process, preferably an aerobic process water treatment, and especially a loop reactor. The loop reactor should have an effective nozzle for mixing the solid and liquid phases in its design. Alternatively or additionally to the aerobic method, a reactor for the anaerobic process water treatment or also reverse electrodialysis (electrodialysis reversal) can be used, particularly for nitrate recovery, distillation, vaporisation and/or ion exchange processes, as well as active coal.

[0142] The cooling of the reaction product, in particular below the boiling temperature at one bar absolute pressure, usually takes place outside the reaction space, also in a device for devolatil-isation. The heat energy released thereby can be made available for other processes via heat exchange processes. Before, during, or after this process, one or several comminution steps take place. For this, mills or pressing methods are preferably used.

[0143] The separation of the solid phase from the reaction mixture usually takes place in the first step in mechanical and in the second step in thermal separation devices. A static thickener is used for reducing water content under gravity with or without a mechanical rotating device or raking machine, for example a stationary thickener or throughput thickener. The feed quantity can be controlled by a dosing device. At accordingly high volumes, the device enables the thickened mixture to be dispensed in even doses and to several machines. The thickener can also be integrated directly into the drying device. An advantageous design of the cone construction makes it possible that the mixture is fed directly into the drying device. With according adjustments to the size of the process, external installations can be foregone. Alternatively, the mixture to be thickened can be dispensed under pressure to an arched sieve surface or curved screen. The resulting centrifugal force presses part of the liquid through the sieve slots. The thickened mixture is collected at the end of the sieving and fed into the drying device. Hydrocyclones offer a further advantageous separation method, in which solids and fluids are separated by centrifugal acceleration. The thickened mixture in the underflow is fed into the drying device and the processed or clarified liquid leaves the hydrocyclone in the overflow. A continuous and optimised feed to the drying device can be ensured by tuned upstream thickening devices and interconnected dosing devices. This is particularly significant in the use of a pusher centrifuge for drying. Pusher centrifuges have high operational safety and are suitable for dehumidifying and washing of granular solids.

[0144] Alongside mechanical devices, which are usually connected upstream of the drying process for energy reasons, thermal drying methods are preferably used. The quantities fed into the drying process weigh over one kilogram. A batch process is preferred to a continuous process. The drying process takes place by means of at least one or several driers or by a combination of different devices for separation and/or drying. A convection drier is for example used for drying the reaction and secondary products. The dry material thereby comes into contact with hot drying gas. It is therein disadvantageous that used gas is to be discharged and must usually be cleaned with dust collectors. Where appropriate, the gas may be returned to the moisture after condensing. A fluidised bed drier can for example be used as convection drier. Spray, nozzle tower or flow driers can also be used depending on the present or desired particle size. A continuous process is advantageous where one or more tray, drum, or tunnel drier is used. When a contact drier is used, essentially only the contact surface is available for heat transfer. A belt, vacuum belt, drum, screw, cylinder, roller, or belt drier, and preferably a vacuum drum filter or drier is used. For achieving lower moisture contents, a disk drier can alternatively or additionally be used, depending on the throughput. The drying process can take place by means of a hot gaseous medium such as air at temperatures between 61 and 95°C, between

65 and 90°C or between 70 and 85°C. Alternatively, in the thermal drying apparatuses, the preferred gas used is not only air but also superheated steam and particularly preferably steam at a temperature of 130-180°C.

[0145] A combined mechanical-thermal method can be used for separation or drying. The advantage of a mechanical-thermal process compared to conventional methods is significantly lower residual moisture in the product, achieving improved conveyability or transportability of the product, especially in fine particle systems or nanosystems. A further advantage is that a partial washout of contaminants from the reaction product takes place using the condensing steam. The use of steam as a potential driving force for further dehumidification brings with it an increase in performance for centrifuges working as filters. The mechanism of the even mechanical displacement by a condensation front cooperates with inertial force and leads to a practically complete emptying of the coarse capillary system of even the smallest of reaction products down to the nanoscopic scale. Steam pressure filtration is, for example, among the methods using this mechanism. Instead of pressurised air, it uses saturated or overheated steam for gaseous pressure-differential dehumidification. Superimposed steam pressure centrifugal dehumidification is especially preferred. The process of combined vapor pressure and centrifugal dehumidification converts the finely dispersed solid of the reaction product from the suspension directly into a process space into a dry, pure, free-flowing, end product according to the application. The residual moisture content of the reaction products according to the application is advantageously about 6-25%, also 10-20% or even 12-15%. The reaction mixture is present as a suspension after the conversion reaction. Depending on the raw materials and process management, the following reaction, intermediate, by-products and / or end products are produced from biomass: fuels from peat to lignite to black coal-like fuels, carbonaceous materials such as insulating materials, nano-sponges, globules, fibers, cables, active or sorption carbon, charcoal substitute, high-density carbon products and materials and, in particular, feed materials for graphite and graphite-containing or similar products, and carbon fibers and feed materials for composites or fiber composites. Pure, purest and ultra-pure coal-like materials belong to the products according to the application. They have advantageous characteristics, which is mainly due to the reduction of mineral materials compared to the feed material. Pure coal is above all the combustible portion of the coal and clean coal is activated carbon. In the case of ultra-carbons, for example, the mineral content is less than 0.1% by weight.

[0146] Organic and also inorganic materials are also extracted from the feed material during the course of the method or the chemical conversion process and are thus made available and more easily accessible. This is partly due to the fact that the substances go into the aqueous phase, in which they partly go into solution. This in turn depends on the reaction conditions. In addition to the organically dissolved and undissolved substances, the substances which have been dissolved out or more readily available include inorganic substances such as alkalis, metals, salts and acids, including humic acid-like substances, calcium, magnesium, chlorine, iron, aluminium, phosphorus, potassium, sodium, nitrogen and their compounds.

[0147] The solid carbonaceous components of the reaction product, which are present as materials and/or fuels after the conversion reaction, have the following characteristics amongst others: The composition of the materials and/or fuels can be controlled by the reaction procedure. The concentration of individual materials cannot easily be varied selectively and independently of other materials. However, different material groups and parameters can be changed in the same direction. For example, during a reduction of the sulphur content, the chlorine and ash content is also reduced at the same time.

[0148] In different measurements by means of elemental analysis, the carbon content of grass, hedge trimming (thuja) and sugar beet was over 50-63% of the percentage mass fraction of the elements (dry matter) and was thereby approximately 20-60% above the mass fraction of the feed material. The oxygen content was reduced by up to half and the nitrogen content by about a quarter and the hydrogen content was reduced to about a quarter. The carbon content of the raw materials and / or fuels is 10-300%, or even 50-300%, or even 100-300%, in particular 200-300% higher than the starting material. The carbon content of the materials and / or fuels is compared to the starting material by 5-200%, preferably 10-150%, more preferably 10-120%, especially 50-100% higher. The carbon content of the fuel and / or fuel is usually between 40-95%, even 50-90% or even 55-80%. The carbon fraction can, in dependence on the reaction procedure and on the feed material, also achieve higher purity degrees of over 98%. The hydrogen content of the material and/or fuel is reduced up to nine tenths to a third, also a third to a twentieth or up to a twentieth to a fiftieth compared to the feed material. The oxygen content of the material and/or fuel is reduced by up to nine tenths to a third, even a third to a twentieth or up to a twentieth to a hundredth compared to the feed material.

[0149] The nitrogen content of the material and / or fuel is reduced to nine-tenths to one-third, even a third to a twentieth or even to one-twentieth to one-hundredth compared to the feed material. The sulphur content of the material and / or fuel can be a content of the biomass and is reduced to nine-tenths to one-third, even a third to a fiftieth or even to a fiftieth to one-thousandth compared to the starting material. The ash content of the material and / or fuel can be a content of the biomass and is reduced to one-nine tenths to one third, even a third to a fiftieth or even to a fiftieth to one-thousandth compared to the starting material. The fine dust content of the material and / or fuel can make up a content of the biomass and is reduced to a nine-tenths to one-third, even a third to a fiftieth or even to a fiftieth to one-thousandth compared to the feed material.

[0150] A reduction of the mineral parts and of the ash and particulate fine dust part during the combustion to a multiple of for example considerably above 300% can be enabled by a high fraction of process water. A dilution of the mentioned contents of substances, but also of numerous other materials occurs by the increase of the proportion of process water, which were originally contained in the feed material and which are removed during the conversion reaction and are dissolved. It could be said that these substances are washed out, so that practically the proportion of soluble substances can be reduced in proportion to the process water fed in the solid phase. Even with the omission of a catalyst component or suboptimal reaction conditions, a higher carbon content can still be achieved which is more than 5-10% higher than that of the feed material. With proper treatment of the biomass and process management, a carbon content of 55-77% can be achieved. With proper process control, low-cost feed materials including coordination of the catalyst mixture, carbon values of 78% and more can be achieved, making it comparable to fossil fuels. After completion of the reaction, the carbon content of the material and / or fuel has indeed increased, but the energy content or the calorific value may have fallen by up to 36%. Due to the release of heat during the reaction because it is an exothermic reaction. Conversely, a total of at least 65% of the original gross calorific value of the dry biomass is retained based on the mass weight of the feed material. If carbohydrate-containing biomass is used as feed material, such as grain, corn or sugar, the calorific value of the material and / or fuel is about 65-85% or in another embodiment 70-80% compared to the feed material. The less carbohydrates the feed material contains, the lower the energy release during the reaction. This involves a higher calorific value of the reaction product compared to the feed material at the same time. The energy contents of the reaction product depending on the biomass used can be described as follows in an exemplary manner: If lignocellulose-containing biomass is used as feed material, such as cut greens or harvest waste, the calorific value of the material and/or of the fuel is about 70-90%, and also 75-85% based on the mass weight of the feed material. If biomass with a low carbohydrate, cellulose or lignin fraction as for example clearing or sewage sludge is used as feed material, the fuel value of the material and/or of the fuel is about 80-95%, and also 85-90% depending on the mass weight of the feed material. Pure, purest or ultra-pure coal can be used in a versatile manner, for example as a basic chemical and feed material for further processing in the chemical industry or as fuel for a carbon fuel cell. During the course of the reaction, numerous materials were dissolved out of the solid phase. These are then present in the fluid phase and are dissolved in the process water. Various minerals such as phosphorous, sulphur, but also nitrate can be recovered from the process water. These can then be used as fertiliser, raw materials or materials in other processes. In order to ensure a natural cycle, it is of interest that mineral components are isolated, particularly from the liquid phase, as these can again be re-introduced to soil as fertiliser for the natural development of biomass. An approximately closed cycle can thereby be maintained, by returning nutrients contained in this biomass to the soil from which biomass was previously extracted for the production process.

[0151] Through depolymerisation and restructuring processes, completely new chemical carbon compounds and structures are formed, particularly agglomerates which can be comminuted with a lower energy input than most known solid fossil fuels. Further, a brown-blackish coloration results depending on the feed material, probably by formation of Maillard reaction products. The density of many feed materials is lower than water prior to the start of the reaction. The density continually increases during the reaction procedure and reaches a density comparable to black coal, depending on the feed material and reaction procedure. While the density of most feed material is 200-600 kg/m3, and occasionally up to 800 kg/m3 (dry weight), the density of the reaction product can reach above 900-

1200 kg/m3, occasionally also values of 1250-1350 kg/m3, assuming that the air between the particles of the reaction products is eliminated or pressed out. By virtue of the small particle sizes of the reaction product, a larger surface area compared to the feed material. This makes the drying with the same moisture content easier than with naturally occurring carbon compounds with a comparable carbon content. At the same time, the large surface area contributes to a lower ignition temperature.

[0152] Differentiating characteristics of the reaction products include:

- The presence of Maillard or Maillard-like reaction products in the liquid and solid phases.
- The strong and intensive odour formation varies with the feed material. The odour formation is causally connected to the formation of Maillard reaction products.
- Improved electrical conductivity compared to other naturally-occurring carbon compounds with a comparable carbon content.
- Turf- to fossil coal-like fuel.
- Less volatile components than conventional or fossil fuels with the same carbon fraction.
- Lower ash formation by combustion, lower content of nitrogen,
- Sulphur, nitrate, heavy metals and reactive, that is, lower self-ignition temperatures than with comparable fossil fuels with a similarly high carbon fraction.
- Advantageous and less damaging flue gases composition from combustion than comparable fossil fuel with a similarly high carbon fraction.

[0153] Altogether, numerous advantages result from the above-mentioned characteristics of the new reaction product and its environmentally and climate friendly characteristics compared to conventional fuels. The treatment method is more efficient and economical for the purpose of industrial production of materials and/or fuels from biomass compared to conventional methods for energy recovery from biomass. With the material conversion of the biomass, practically no carbon need be lost. Usually more than 95% of the carbon contained in the feed material passes into the solid components of the reaction product, which can be used for energy recovery. The remainder of the carbon compounds are found in the liquid phase. During the conversion reaction in the reactor, practically barely any noteworthy amounts of carbon dioxide or other climate-damaging gases are released. About 1-4% of the feed material carbon can be found in the liquid phase. The fraction therefore depends on the course of the process, particularly on the carbon content of the feed material and liquid-solid ratio of the reaction mixture.

[0154] Carbon-containing nanomaterials and structures are formed by the reaction procedure, in particular by the choice and composition of the feed material and catalysts. These materials exhibit in part useful material and surface characteristics. Among these are, for example, nano-sponges which can be used as water reservoirs or insulating materials. The so-called Maillard reaction takes place in heating processes such as baking, frying, roasting, grilling and deep-frying of proteins or albuminous and carbo-hydrate-rich food at temperatures over 130°C. During the course of the so-called Maillard reaction, red to yellow-brown, sometimes nearly black-coloured polymers, the melanoidins, arise from carbohydrates and amino acids in addition to a multitude of flavouring agents. Through high temperatures as occur during baking and roasting, but also through higher pressures, the reaction is accelerated and particularly many and dark melanoidins are formed. They therefore make up a not-insignificant proportion of products such as bread, coffee, malt, nuts or cornflakes – they are for example up to 30% of coffee.

[0155] Maillard or Maillard-like reaction products are formed in high concentrations during hydrothermal carbonisation. In the solid as in the liquid phase (e.g. process water), there are relatively high concentrations of indicator substance CML, which are usually between 0.3-2 mmol/mol lysine. Higher concentrations are usually present in the liquid phase, that is, in the process water, than in the solid phase of the reaction product. The concentrations or concentration ratios depend on the solid-fluid ratio and composition of the feed material and the method procedure. Antioxidant and chemo-preventive characteristics are assigned to CML. It is therefore to be assumed that comparable or similar characteristics can also be found in other intermediate, secondary or reaction products of hydrothermal carbonisation, including Maillard or Maillard-like reaction products. Insulation and cleaning of the Maillard or Maillard-like reaction products take place, amongst others, by means of filtration, ultrafiltration and/or chromatographic methods, particularly by means column chromatography.

[0156] The humus produced in the method results from a comparably shorter dwelling time compared to reaction products with a higher calorific value.

It usually still comprises the fibre-containing material (amongst others lignin and cellulose) of the feed material. The biopolymers are not completely depolymerised. The humus produced comprises a carbon fraction of at least 30-45% and a heating value of at least 15-24 MJ/kg and can be burnt well. The humus produced according to the method of the application can partially have similar characteristics to natural humus and partially also to turf or peat.

[0157] The above characteristics for the reaction products of the method of the application apply to the combustion characteristics. Certain materials can be enriched in the humus by an optimised process method, in particular through the concentration difference between the solid and liquid phase within the reaction mixture. This is desired during the use of humus as a CO2/carbon sink or fertiliser. Unlike this, during the processing or admixing of humus into products, where an enrichment of certain materials is not desired, an enrichment of mineral materials and alkalis and other substances which are detrimental for the product's application is avoided. The humus produced is a uniform humus and fuel, the characteristics of which can be calculated and controlled through the composition of the feed material and catalysts, as well as the process method, and can be produced within hours. The method is therefore considerably faster than other known humus production methods, which usually take weeks or months.

[0158] The materials and/or fuels produced according to the application including turf or peat or turf or peat-like materials have the following characteristics:

- Through the method according to the application, turf- to black coal-like fuel results from biomass.
- The calorific value depends on the process method, particularly the reaction duration. The calorific value increases with reaction duration or dwelling time in the reactor.
- Fewer volatile components than conventional or fossil fuels with the same carbon fraction.
- The energy yield compared to coal is 0.7-0.95. The lower the carbohydrate content, the higher the energy yield.
- 90-95%: lignins, specifically bacterial biomass.
- The fuels are more reactive and have lower self-ignition temperatures than comparable fossil fuels with a similar carbon fraction.

- Fossil fuels such as lignite or black coal have indeed similar heat values compared to fuels produced by hydrothermal carbonisation through methods in accordance with the application, but are distinctly different to fuels with regard to composition and characteristics.

[0159] The different types and varieties of fossil coal have very different chemical compositions and characteristics, depending on the point of origin and mining area, so that every type of coal has unique and unmistakable characteristic features. For example, the heat value of fossil Lausitz raw lignite is 8,700 kJ/kg, the water content about 56%, sulphur content about 0.7%, and ash content about 4.5%. The water, sulphur, and ash content of the fuel are all lower, while the calorific value is usually clearly above 20,000 kJ/kg. Irrespective of water content, 1 kilowatt-hour of energy can be generated from 1 kilogram of fossil Lausitz raw lignite in Lausitz. In contrast, more than double the power can be generated from the same amount of fuel. As opposed to fossil coal, in the material and/or fuel according to the application there are easily detectable concentrations of Maillard reaction products. NE-(carboxymethyl) lysine (CML) has established itself as indicator. This compound is detectable in the liquid as well as the solid phase of the reaction products. Concentrations of 0.2 to over 1.5 mmol/mol lysine were measured, where higher proportions were measured in the liquid phase than the solid phase. The distribution of the concentrations depends on the feed material, reaction conditions, and process method. After mining, fossil coal is present in clumps or, depending on the mining depth, in relatively highly compressed agglomerates, which must be comminuted under high energy. Furthermore, it must be dried and milled to a fine lignite or coal dust in coal mills. By contrast, materials and/or fuels after the end of the process are present as small particles with a size of usually less than 1 millimetre to less than 30 nanometres and can be dried more easily due to their large surface area. With this, the energy requirement for conditioning and particularly drying of fuels is considerably lower compared to solid fossil coal.

[0160] In particular, the combustion characteristics of the fuel are more advantageous, not only in comparison to types of fossil coal, but also compared to most of the currently available fuels from renewable raw materials. At least one, but often several or all of the following parameters are more favourable with the fuels, particularly compared to the feed material, specifically alternative fossil or biomass fuels: reduced ash content, less chlorine, nitrate, sulphur, heavy metals and lower emissions of dust, fine dust and gaseous toxic substances including nitrogen and sulphur oxides. This is also valid for compacted forms of the fuels such as briquettes and pellets.

[0161] The quality of the fuel and the combustion characteristics depend on:

- The feed material or the mixture of feed material, on the process method, on the catalyst mixture and on the composition of the process water.
- Feed materials with high proportions of fat and energy content lead to
- Fuels with higher heat values. For example, during the processing of particularly suitable sludges, heat values of up to 34-36 MJ/kg can be achieved.
- Ash content after the combustion of fuel with a calorific value of 30-33 MJ/kg is reduced by up to 75% or more compared to feed material with a calorific value of 17-20 MJ/kg.
- Sulphur content following combustion of the fuel with a calorific value of 30-33 MJ/kg is reduced by up to 50% or more compared to the feed material with a calorific value of 17-20 MJ/kg.
- Fine particulate matter and gas emissions are lower compared to the feed material.
- The combustion result is determined by the combination of the process method, conditioning-dependent fuel quality and combustion technique.
- The fuel is a uniform fuel, the characteristics of which can be calculated and controlled via the composition of the feed material and the catalysts, as well as the process method.
- In addition to the aforementioned differences in the combustion characteristics, these are additional differentiating characteristics to fossil fuels such as black coal, lignite or peat.
- Pure, purest and ultra-pure-like materials also belong to the products according to the application. They have advantageous characteristics, which can mainly be ascribed to the reduction of mineral materials compared to the feed material. Pure coal is mainly to be understood as the combustible fraction of the coal, and purest coal is also to be understood as active coal. The mineral content of ultra-pure coal is for example under 0.1% of its weight.

[0162] Depending on the application of a device, different process steps can be combined in one unit. The comminution and mixing can for example proceed in a single mill or the drying and comminution can take place in an air vortex mill. All devices or devices mentioned in this patent specification are provided or equipped with a control, regulation, extensive automatisation, as far as this is sensible in a process-technical manner, can be depicted economically, and is technically possible. The same is valid for all mentioned procedures, methods, or process steps.

[0163] Double-stranded hydrolysis or reactor batch feeding for HTC and TDH: the invention is explained in more detail in an exemplary manner in the following by means of the drawings described in the following.

SHORT DESCRIPTION OF THE DRAWINGS

[0164] FIG. 1 shows an example of a schematic depiction of a plant in particular consideration of a double-strand feed device.

FIG. 2 shows an example of a schematic depiction of reactors arranged in parallel with respectively a reactor connected downstream.

FIG. 3 shows an example of a schematic depiction of a plant for thermally-induced hydrolysis.

[0165] FIG. 1 shows an example of a schematic depiction of a plant with special consideration for a double-stranded batch feeding device for the method according to the invention. The device consists of feed strands I and II and devolatilisation strand III. Strand I serves to feed feed materials with a high solid content, of for example 3-50% of the total volume. For this, the "dry" biomass is stored in a hopper (1) and brought from there to a vessel (2), preferably a moving floor container (2). The feed materials are fed into a comminution device (3), implemented for example as a wet or dry mill, or as another suitable mechanical comminution unit, via a conveying device, which can for example be a screw conveyor or conveyor belt, and are fed from there into a mixing vessel (6). The dry biomass is mixed thoroughly with concentrated process water from the reservoir (4) and at least one catalyst from the vessel (5) in the mixing vessel (6) by means of an agitator. The mixture is fed into the incubation vessel (8) via the conveying device (7). The incubation vessel (8) enables an exposure period of the catalyst on the material. The vessels (6) and (8) are double-walled and have a hot water connection, so as to enable a preheating of the material to 50-60° C. Via the conveyor devices (9) and (10), which are for example designed to be screw conveyors or conveyor belts, the incubated material of the "dry" feed materials is fed via a feed device (21) from the first feed strand I to the first reactor (19) under pressure above the vapor pressure of the process water. The feed device consists of a force conveyor, which is for example an injector, double screw extruder, eccentric spiral pump, piston pump, spiral displacement pump, respectively equipped with or without compressor screws or double screw compressor. The feed device (21) can additionally be provided with a shutoff device. The feed device (21) ensures that the incubated material from the strand I with a pressure level above the inner reactor pressure is brought into the reactor (19) and prevents backflow into the feed device.

[0166] Via feed strand II, pumpable feed material with a solid content of 3-50% of the total volume is transferred to a mixing device (14) from a storage vessel (12) by means of a conveying device (13), mixed in the mixing vessel (14) with process water from the reservoir (4) and a catalyst from a vessel (15), incubated in an incubation vessel (16), and fed to the reactor (19) via a suitable conveyor device (17), which can for example be designed to be a piston, spiral displacement, or eccentric spiral pump. The material is heated to at least 160-180, 200-220 or 220-250°C via the heat exchanger unit (18). The feed materials which have been pre-treated as such from feed strand II are fed into feed strand I via the feed material which has beforehand, in parallel, or afterwards, been fed or submitted into the reactor (19), via the described or other appropriate conveyor devices. The ratio of the mass flow rate of feed strand I to feed strand II or of presented to fed feed materials is for example 1:20, 1:5, 1:1, or 10:1. An even mixture of the presented or rather of the fed material takes place in the first reactor via a mixing or stirring device (20). The heating and discharge of exothermicity occurring in the reaction takes place via a heat exchange device (22) in connection with the double wall (23) of the reactor (19) and/or other heat exchangers brought into the reactor or which are in connection with the reaction mixture. These can for example take the form of spiral, tubular, bundle or spiral heat exchangers. After the necessary dwelling time, the content of the reactor (19) is transferred to a second reactor (24) using a pressure drop.

[0167] In addition, a conveyor can be used for accelerating fluids. The second reactor (24), situated in terms of the flow direction behind the first reactor (19), has a smaller volume. As process water is withdrawn by means of a solid-fluid separation device described in another location, the volume of the reaction mixture is reduced. Lower reactor volumes or smaller reaction spaces are thereby needed in the further course of the process.

[0168] The withdrawal of process water simultaneously enables the merging of the diminished reaction volumes from different parallel reactors or specifically of reaction mixtures which are merged in a single reactor in a parallel or time-delayed manner with a reaction stage deviating up to 50% of the total reaction time or with a reaction time deviating up to 50%. The volume of this reactor is for example 5, 10, or 20% below the volume of the sum of all reactor volumes, from which the reactor receives the reaction mixture.

[0169] The reactor (24) is also equipped with heat exchanger device (22), a stirring device (20), and a double wall (23), and keeps the temperature constant at the level necessary for the reaction over the length of the dwelling time. The released reaction heat is discharged via the heat exchanger device (22), through which a cooling is achieved. After the expiration of the dwelling time for the reactor (24), a devolatilisation of the material in the devolatilisation vessel (26) takes place via the heat exchanger unit (25). The material can also be treated thermally via stirring device (20), heat exchanger device (22) and double wall (23). The heat exchanger (27) ensures a cooling of the material to temperatures below the evaporation temperature of water. The flow and the pressure devolatilisation are thereby controlled thereby via a backwards-facing devolatilisation pump, which takes the form of a force conveyor, eccentric spiral displacement or piston membrane pump.

[0170] The wet feed material is stored in a devolatilisation vessel (29). Accumulated heat can be discharged via its double wall. Excess process water is separated via the subsequent solid-fluid separation (30), which is designed to be a decanter, centrifuge, cyclone, filter chamber press, filtration device, or a device for separation or drying serving for the same purpose or mentioned in another part of this specification, and the process water is again made available for other processes within the method. The final product is stored temporarily in the store (31) for further use.

[0171] The feeding of a first or several first reactors can also take place via a single feed strand, that is, via feed strand I or II alone or independent of a second feed strand. This is unproblematic if "damp" feed materials are fed. But if a reactor is filled with "dry" and free flowing feed material, a sufficient supply of water has to be considered. The use of process water or enriched process water at temperatures of over 60, 100, 160 or 200°C is thereby advantageous, where a filling just, that is up to 5, 10, 40 or 60% below the free-flowing pile or of the filling level of the "dry" feed material is sufficient. The filling height with process water within the reactor depends, amongst others, on the bulk density and other consistencies of the feed material.

[0172] So as to increase the throughput of feed material or the yield of the fuel or material according to the invention, the setting to a solid content as high as possible is necessary. The limiting factor for maximising solid content is the pumpability of the predominantly wet biomass on the one hand, and the conveyability independent of a pump of dry biomass connected to the reactor input on the other hand. At the same time, it has to be considered that a preincubation also has to be carried out for dry biomass. The use of feed material at a particle size as small as possible as described in another part of this specification is thereby usually sufficient. The decrease of the viscosity in the course of the charging method can be seen as measure of the progression of the pre-treatment. The viscosity of the solid-fluid mixture decreases when progressing through the charging device and is reduced to over three quarters, to over half or to over a fifth of the viscosity of the feed material at the end of the process. However, it is valid for the viscosity measurement, that no water was withdrawn or evaporated during the conversion process, that is, between measurements.

[0173] FIG. 2 shows an example of a schematic depiction of reactor arranged in parallel (19) and (24), each with a reactor (32) and (33) connected downstream. The elements of the plants otherwise coincide with FIG. 1 and are thus designated with the same reference numerals. Reactors (19, 24 or 32, 22) are meant to be a reactor configuration where several reactors are filled or emptied in parallel, so that a continuous inlet and outlet flow is achieved. An inlet and outlet flow are continuous if at least 10-30%, 30-60% or 60-90% of the reaction time are flowed through devices connected upstream or downstream of at least one reactor. These devices include heat exchangers for heating and cooling the reaction mixture.

[0174] Through a parallel arrangement, it is enabled that each reactor can be filled or emptied independently from each-other. While a first reactor is filled and a second reactor is emptied, the reaction volume will be held in a third reactor under operating conditions for a time period of 10-100, 100-300 or 300-1600 minutes. If a first reactor is filled, it becomes a third reactor, that is, it takes on the function of a third reactor, in that a dwelling time of at least 1-9, 10-30, 30-60 or 60-99% of the reaction time is enabled. If a second reactor is emptied, it becomes a first reactor, that is, it takes on the function of a first reactor which is filled again. A third reactor can also consist of an indefinite number of reactors.

[0175] Intake and output streams can also be divided into branching streams, so that several reactors can be filled or emptied simultaneously, offset in time or intermittently. Thus, there can also be any number of first and second reactors. In a time-offset branched intake stream, after filling a first reactor, the feed stream is switched over to a second reactor to be filled. In the same way, a time-offset branched intake stream, after filling a first reactor, the feed stream is switched over to a second reactor to be filled. As a result, the feed and discharge flow is maintained thereby.

[0176] A parallel branched stream comprises a branched stream of the same batch or treated reaction mixture, of which the duration of the reaction differs by no more than 1-5, 5-10, 10-30, 30-60, or 60-80%. Analogously to the cascade reactor, in the case of multiple reactors connected in series, so that the output stream of one reactor corresponds to the intake stream of the next, multiple parallel reactors can be known together as a parallel reactor.

[0177] A reactor filling is known as a batch. A batch is the introduction of reaction mixture or a partial flow in a self-contained reactor space concluded. If the components of the solid-fluid mixture are removed, the volume of the batch is thereby decreased. To save the reaction space, it is fed to a subsequent reactor of lesser volume than the preceding reactor. Reaction streams from more than one reactor can be combined in one reactor. The reactor volume of the target reactor, in which batches of at least two reactors are combined, is smaller than the sum of the upstream reactors. This reactor configuration is referred to as the decrescendo cascade reactor. All reactors used are connected in parallel and in such a way that feed and output streams can also be passed as part streams from each reactor in each reactor. By separately controlled valves at all inlet and output streams, the reaction chambers are separated from each other.

[0178] Due to the energetic use of biogenic residual materials and agricultural products and the sanitation conditions, a thermal pre-treatment of biomass gains increasing importance. By the hydro-lysis and in particular the so-called thermo-pressure hydrolysis or thermally induced hydrolysis, which precedes a fermentation or other processes for energy production from biomass, a better digestion of lignocellulosic biomass such as wood, grass and green waste is achieved, so that it is better, faster and more fully accessible to microorganisms and fuel production. Furthermore, highly infectious material is sanitized and thus offers a cost-effective and safe alternative, for example, to animal meal production. Applying this hydrolysis process eliminates the need for animal meal which may be difficult and expensive to dispose of.

[0179] The treatment of organic waste by fermentation, after application of a hydrolysis process, results in a reduction of biomass use of 10 to 20 or 20 to 30 or more percent, based on the organic solids content, to produce the same amount of energy. Different methods for the pre-treatment of biomass prior to introduction into a fermenter of a biogas plant were suggested. Among these, a so-called thermal pressure hydrolysis was developed a few years ago, where the feed materials are passed through a loop reactor (DE19723519) or hydrolysis reactor (DE3928815) and are heated to a temperature of 180°C. The implementation of a microbiological hydrolysis was suggested in a tubular reactor (DE4403391). With the so-called thermal pressure analysis or thermally induced hydrolysis, biomass is treated over a period of about 20 minutes. This is a clearly lower period compared to the hydrothermal carbonisation.

[0180] In recent years, several plants were constructed for the thermal pressure hydrolysis at 180°C as a tubular reactor. Despite expected high efficiency yields, a wide use failed to appear in practice. Several pilot plants have been unable to achieve the desired solid contents continuously, as it repeatedly came to caking and clogging formed as tubular reactor heat exchanger. These problems lasting for years could only be avoided by reducing the solid content, which reduced the yield of hydrolysed or heated material so that economic feasibility of this technology could practically not be achieved.

[0181] The sedimentation behaviour of biomasses and the swelling behaviour of polymer structures in lignocellulosic biomass and of starch in agricultural products was probably underestimated during heating. Swelling is a reversible volume increase of a solid through exposure to fluids, vapours and gases. The polymer structure swells by means of water inclusion. A physical and chemical swelling process are differentiated. In the case of physical swelling, for example, the water seeks a place in the pores of the wood and the interstices. The resulting surface tension between the water and the wood is also called capillary force. In addition to this physical process, there is a chemical swelling process in which water accumulates by its hydrating effect via hydrogen bonds to hydrophilic structures, such as OH groups in amino acids. In plant structures, water is stored between polysaccharides in the cell wall. During the swelling process, there is a temporary formation of gelatinous and colloidal structures, which dissolve again during further process of heating. Also, certain protein substances such as glue-like substance from bone and skin waste can swell in water.

[0182] Starch occurs in nature in the form of starch granules, which can be elutriated or suspended in cold water. When such a suspension is heated, the starch granules begin to swell. This mainly takes place between 47 and 57°C. At higher temperatures between 55-86°C, the starch granules dissolve. The starch which consists of amylose and amylopectin gradually leaves, for example at 62.5°C with potato starch and 67.5°C with wheat starch. The viscosity of the solution thereby increases considerably, and it forms a gel. Gels are traditionally also called paste, as they often behave like paste. The entire process of starch swelling and gel formation is therefore called gelatinisation. The starch paste has different steiffness depending on the type of starch. The swelling behaviour is increased again by pressure and heat and proceeds in an accelerated manner under the conditions of a thermally induced hydrolysis.

[0183] Since maize silage is a commonly used biomass for the production of biogas, in hydrolysis processes, the high stiffness is particularly important to avoid blockages of heat exchange systems. It should be considered that a low starch content, for example below 5 percent, can improve pumpability under certain conditions and especially at constant temperature and pressure ratios. However, as the pressure and the temperature increase rapidly in the thermally induced hydrolysis, an increase in volume and thus an increase in flow resistance can be anticipated. Biomass or feed materials with high starch contents of, for example, about 10 - 30, 30 - 50 or more than 50 percent based on the dry matter are guided directly into the first reactor via the strand for "dry" biomass, i.e. the feed strand I , and are coated there with liquid heated biomass from feed II and/or mixed. Biomass or low starch feedstocks below 3, 5, or 10 percent by dry mass, which are pumpable simultaneously with or without pre-treatment, are passed through the feed strand II. The cause of the increased formation of deposits and blockages is probably due to a combination of factors. For the increase in volume, process gas formation in the heat exchanger as well as starch swelling play a role. Ideally, a stopper flow is assumed with a tubular reactor. A volume increase due to gas formation or swelling is therefore to be expected with pressure increase. This is additionally increased by the increase in viscosity by starch swelling of the conveyed material. This also increases the flow resistance.

[0184] In all built plants for thermo-pressure hydrolysis formed as a tubular reactor, heat exchangers were installed horizontally, i.e. perpendicular to gravity due to the considerable lengths of the straight tube sections. In order to improve the thermally-induced hydrolysis or the heating process of biomass, in particular with regard to the higher yields based on the solids content, the present invention proposes a process for the hydrolysis or heating of biomass, which is characterized in that the solid-fluid mixture for heating passes through a heat exchanger and the solid-liquid mixture is passed to prevent caking and / or blockages substantially parallel to the gravitational force through the not curved tube sections.

[0185] Within the heat exchanger, flowable conveyed material should move downwards on its own and without considerable impact from forces other than gravitational force, so as to prevent caking and blockages. Therefore, the heat exchanger is designed in such a manner that the angle of the tube axis to the horizontal plane is larger than 4 or 7 or larger than 10 degrees in the embodiment. The heat exchanger consists of at least 20, 40 or 60% of vertical tube parts. Vertical tube parts are the parts of the tubes carrying the media, whose angle of the tube axis to the vertical plane is at the most 70 or 50 or 45 degrees. Vertical means an angle of below 45 degrees to the vertical, where the angle of the vertical tube parts is at the most 10 degrees to the vertical in the embodiment.

[0186] The heat exchanger consists for example of a tubular reactor or a tubular bundle or plate heat exchanger or a combination of these devices. The heat exchanger is designed in a modular manner and can consist of different modules, units or sections. The modular units are arranged in spatial vicinity to each other, such that several heat exchanger units can be connected in series.

[0187] The tempering system of the heat exchanger consists of a double wall, with a heat energy carrier medium flowing between the walls. The heat energy carrier medium is for example a thermal oil, water vapour, or process water from the method according to the invention or another process. Different heat carrier media can also be combined. The target temperature of this medium is between 60 and 350°C. The temperature in a first section or module is for example at 60-100 or 80-120°C, in a second section or module between 100 and 140 or 120 and 160°C, in a third section between 140 and 180 or 160 and 200°C, and in a forth section between 180 and 220, 200 and 240, or 240 and 350°C. The temperatures of the heat carrier medium can also be varied by up to 20, 40 or 60°C. The units, modules or sections of the heat exchanger are connected in series in such a manner that the temperature of the solid-fluid is brought again to a lower inlet or outlet temperature after reaching a highest or peak temperature of for example 220-260°C. The heat exchanger is equipped with a hydrolysis reactor which keeps the material at a level of for example +/−2 to 8°C and ensures a residence time of for example at least 20 minutes corresponding to the regional sanitary regulations.

[0188] FIG. 3 shows for example a schematic depiction of a plant for thermally induced hydrolysis with a double-stranded feed. The device for hydrolysis consists of feed strands I and II and devolatilisation strand III. Strand I serves for conveying feed materials with a high solid content. For this purpose, the "dry" biomass is stored in a hopper (1) and brought to a moving floor container (2) from there. Through a conveyor, which may be for example, a screw conveyor or a conveyor belt, the feed materials are conveyed into a comminution device (3) and from there into a mixing container (6).

[0189] In the mixing vessel, the dry biomass is thoroughly mixed with concentrated process water from the reservoir (4) and the catalyst dosing feeder (5) by means of a stirrer. Via a further conveying device 7, which may be, for example, a screw conveyor or a conveyor belt, the mixture is fed to the incubation container 8. The incubation container allows a residence time of the catalyst on the material. The containers (7) and (8) are double-walled and have a hot water connection to allow a preheating of the material to 50 - 60 ° C.

[0190] The incubated material of the "dry" feed materials is fed via conveyor devices (9) and (10) to the reactor feed device (21). The feed device consists of a force conveyor, which is for example an injector, double screw extruder, an eccentric spiral pump, a piston pump, a spiral displacement pump, which are respectively equipped with or without compressor screws or a double screw compressor and is provided with stopping devices. The feed device ensures that the incubated material from strand I with a pressure above the inner reactor pressure is brought into the reactor (19) and prevents backflow into the feed device.

[0191] Via feed strand II, pumpable feed materials with a solid content of 3-50% of the total volume (14), with process water (4) and catalyst (15), are mixed and incubated (16) in the mixing vessel and fed to the reactor via a suitable conveyor device (17) (e.g. piston, spiral displacement, or eccentric spiral pump). The material is heated to least 180-200°C by the heat exchanger unit (18). A single hydrolysis reactor (40) replaces the reactors (19, 24, 32, 33) in FIG. 1 or 2. The elements of the plant otherwise correspond with FIG. 1 or 2, so are provided with the same reference numerals. In the hydrolysis reactor (40), fluid and pumpable biomass from feed strand II is mixed with dry biomass from feed strand I. The dry biomass from feed strand I is fed into the hydrolysis reactor (40) via a suitable introduction device (41). The material can additionally be influenced thermally via a heat ex-changer (42) and the double wall (43) of the hydrolysis reactor (40).

[0192] At the end of the reactor’s (40) dwelling time, devolatilisation of the material takes places in the devolatilisation vessel (29) via the heat exchanger (27). The heat exchanger (27) ensures a cooling of the material to temperatures below the evaporation temperature of water. The passage and pressure of the devolatilisation are thereby controlled via a backwards-oriented devolatilisation pump, which is designed as a force conveyor, eccentric spiral, spiral displacement or piston membrane pump.

[0193] The wet feed material is stored in the devolatilisation vessel (29). Accumulated heat can be discharged via the double wall. In the subsequent solid-fluid separation (30), designed to be a decanter, centrifuge, cyclone, filter chamber press, filtration, or device used for a similar purpose or described in another part of the specification, excess process water is separated off and made available for other processes within the method according to the invention. The final product is temporarily stored in the storage container (27) for further use.

[0194] The hydrolysis method is operated continuously to a large extent. This means that the time period in which feed materials are brought into the process via a reaction cycle, or rather via a heat exchanger unit (18) for the time necessary for the passage of the material, amounts to at least six tenths of the reaction cycle. In an offset manner, the same period applies for the filling process into the heat exchanger (27), the devolatilisation vessel (29), or for cooling. Throughput of the plant is therefore defined by the conveying device (17) and input device (19). The rotation speed of the backwards-acting devolatilisation pump (28) is controlled through pressure sensors at different locations of the plant in such a way that evaporation of the material is prevented by the existing pressure in the plant. A valve for devolatilisation can also be used as an alternative to a devolatilisation pump.

[0195] The devolatilisation device or pump (28) is controlled by temperature and/or pressure. A longer dwelling time in the heat exchanger is achieved by a reduction of the rotation speed. Reducing the temperature of the medium. The temperature is adjusted in such a manner as is necessary in the following device or in the subsequent process. If the reaction mixture is, for example, further guided into a vessel with ambient pressure, adjustment to a temperature below the boiling point is necessary to avoid undirected and uncontrolled evaporation processes. Upon feeding into a drying process, temperatures above the boiling point may be desired depending on the implementation in effect, some of which are described elsewhere in this patent specification. The devolatilisation pump (28) is controlled in such a manner that the remaining residual pressure is sufficient for the conveyance in a subsequent process or a device. The residual pressure is for example below 10, 5, 2 or 1 bar.

[0196] The layout of a plant for thermally-induced hydrolysis with a double-stranded feed and a double-stranded feeding device for the production of fuel/material, in the method according to the invention, are similar in some points; some devices and layout forms are therefore interchangeable. All devices in connection with a double-stranded feed material supply are equipped, as far as is technically and economically possible, with control, regulation, and advanced automatisation. The same is valid for all mentioned processes, method or process steps.

[0197] The decrease in viscosity over the course of the process can be seen as a measure of the progress of the hydrolysis. The viscosity of the solid-fluid mixture is reduced when passing through the hydrolysis device and is reduced to at least three quarters, half, or a fifth of the viscosity of the feed material. Adjusting the solids content to be as high as possible is necessary to increase the throughput of the feed materials and accordingly the yield of the hydrolysed material. The limiting factor for maximising the solid content is the pumpability of the mainly wet biomass on the one hand, and the conveyability, independent of a pump, of largely dry biomass in respect to its introduction into a reactor on the other.

[0198] The purity of the carbon present in the solid-fluid mixture increases through numerous additional washing steps, which develop a higher efficiency through high pressure and temperature. The sulphur and/or ash content of the solid-fluid mixture is thereby reduced by at least 50% or 75% in relation to the original content of the respective carbon-containing component. The sulphur and ash contents can be reduced by more than 80, 90 or 99% in relation to the original content of the respective carbon-containing component. In other words, the sulphur and ash content is reduced continuously during the course of the reaction process in connection with washing processes, and it is reduced to over two tenths, one twentieth, or one hundredth of the sulphur and ash content of the feed material towards the end of the process.

LIST OF REFERENCE NUMERALS

1.	Hopper
2.	Vessel
3.	Comminution device
4.	Reservoir
5.	Container
6.	Mixing vessel
7.	Conveying device
8.	Incubation vessel
9.	Conveying device
10.	Conveying device
11.	-
12.	Storage container
13.	Conveying device
14.	Mixing vessel
15.	Container
16.	Incubation vessel
17.	Conveying device
18.	Heat exchanger unit
19.	Reactor
20.	Stirring device
21.	Introduction device

22. Heat exchanger device
23. Double wall
24. Reactor
25. Heat exchanger unit
26. Devolatilisation
27. Heat exchanger
28. Devolatilisation pump
29. Devolatilisation vessel
30. Solid-fluid separation device
31. Storage
32. Reactor
33. Reactor
34. -
35. -
36. -
37. -
38. -
39. -
40. Hydrolysis reactor
41. Introduction device
42. Heat exchanger
43. Double wall

PATENTKRAV

1. Fremgangsmåde til fremstilling af materialer eller brændstoffer ud fra en fast-flydende blanding af vand og en carbonholdig bestanddel, hvor den faste-flydende blanding behandles ved en temperatur på over 100 °C og et tryk på over 5 bar i mindst én reaktor (19), hvor ikke-pumpbare første udgangsmaterialer føres via en første tilførselsstreng (I) ind i den mindst ene reaktor (19), **kendetegnet ved, at** der samtidigt eller med en tidsforskydning tilføres pumpbare anden, opvarmede udgangsmaterialer via en anden tilførselsstreng (II) ind i den mindst ene reaktor (19).

2. Fremgangsmåde ifølge krav 1, hvor de ikke-pumpbare første udgangsmaterialer, der føres via den første tilførselsstreng (I) ind i den mindst ene reaktor (19), har et faststofindhold på 25-97 %, og de pumpbare anden udgangsmaterialer, der føres via den anden tilførselsstreng (II), har et faststofindhold på 3-50 %.

3. Fremgangsmåde ifølge krav 1 eller 2, hvor de ikke-pumpbare første udgangsmaterialer fra den første tilførselsstreng (I) føres ind i reaktoren (19) ved et tryk over procesvandets damptryk.

4. Fremgangsmåde ifølge krav 3, hvor tilførselsanordningen (21) til indføring af de ikke-pumpbare første udgangsmaterialer fra den første tilførselsstreng (I) i reaktoren (19) ved et tryk over procesvandets damptryk er en injektor, en dobbeltsnekke-ekstruder eller en dobbeltsnekke-kompressor.

5. Fremgangsmåde ifølge krav 1 eller 2, hvor de ikke-pumpbare første udgangsmaterialer tilføres reaktoren (19) via den første tilførselsstreng (I), og de pumpbare anden, opvarmede udgangsmaterialer samtidigt ledes via den anden tilførselsstreng (II), og hvor forholdet for masse-gennemstrømning mellem ikke-pumpbare første og pumpbare anden udgangsmaterialer udgør 1:20-10:1.

6. Fremgangsmåde ifølge krav 1 eller 2, hvor de ikke-pumpbare første udgangsmaterialer fra den første tilførselsstreng (I) tilføres på forhånd ved et tryk under procesvandets damptryk og overlejres af de pumpbare anden opvarmede udgangsmaterialer fra den anden tilførselsstreng (II), og hvor forholdet for masse-gennemstrømning mellem de ikke-pumpbare udgangsmaterialer, der er tilført på forhånd, og de tilledte anden udgangsmaterialer udgør 1:5-1:1.

7. Anordning til behandling af en fast-flydende blanding af vand og en carbonholdig bestanddel ifølge fremgangsmåden ifølge ét af de foregående krav,

omfattende en reaktor (19) og en første tilførselsanordning (21) til ikke-pumpbare udgangsmaterialer, **kendetegnet ved, at** der er tilvejebragt en anden tilførselsanordning til pumpbare udgangsmaterialer, der omfatter en pumpe (17) til tilførsel af faste-flydende blandinger, og en vertikalt anbragt varmeveksler (18), der er placeret på nedstrømssiden deraf.

8. Anordning ifølge krav 7, hvor pumpen (17) er udformet til udgangsmaterialer med faststofindhold på 5-10 % eller 10-25 %.

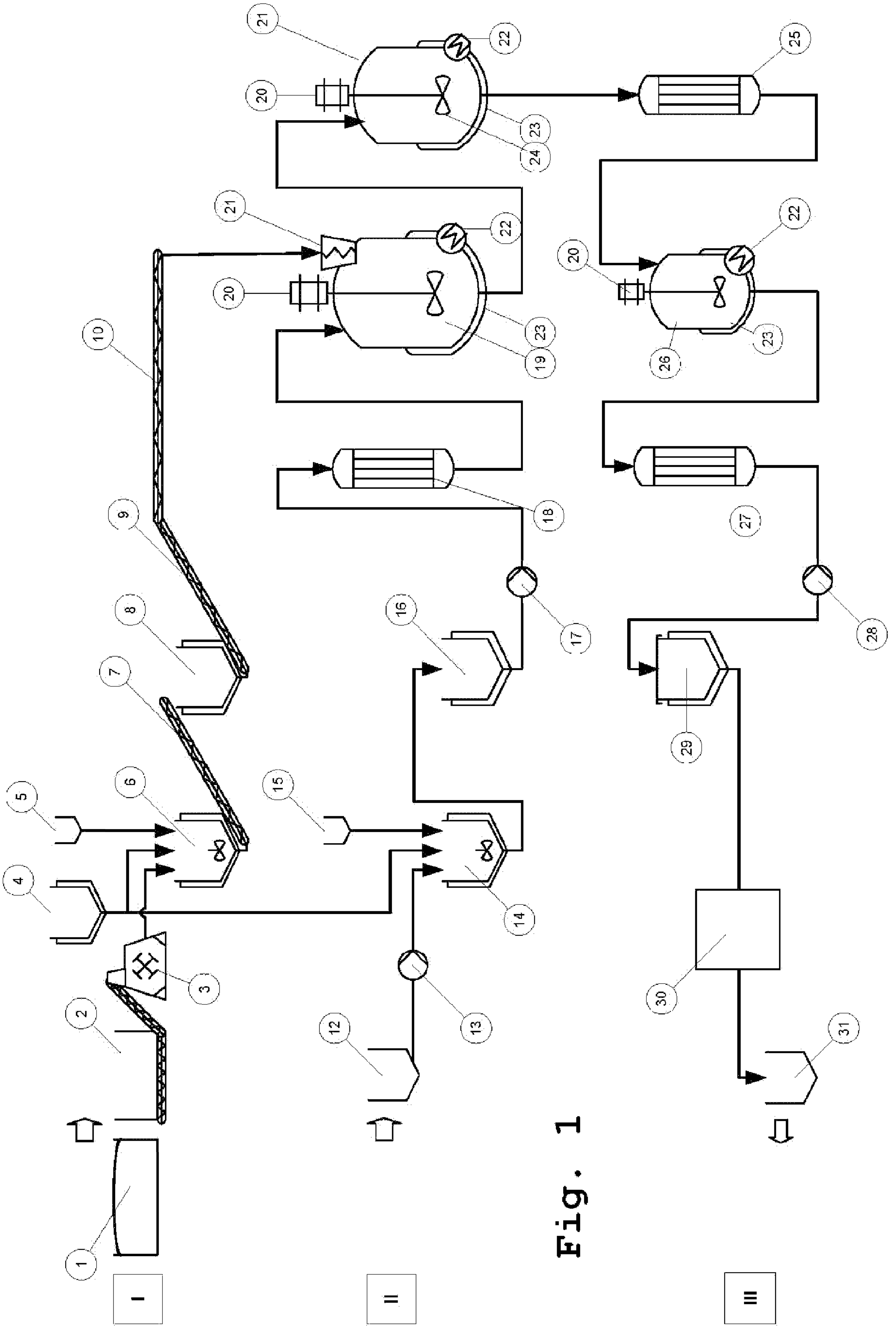
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Fig. 1

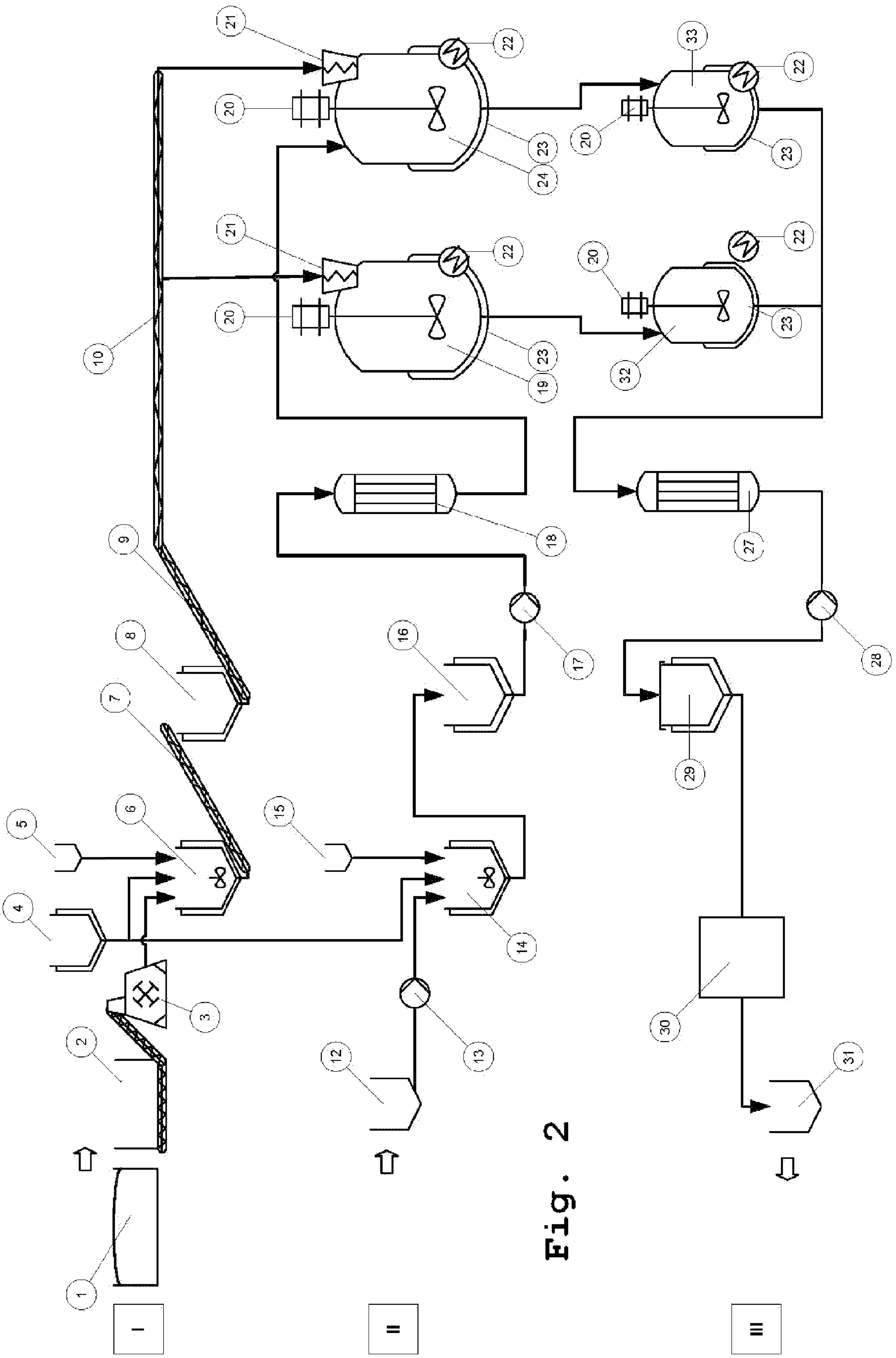
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Fig. 2

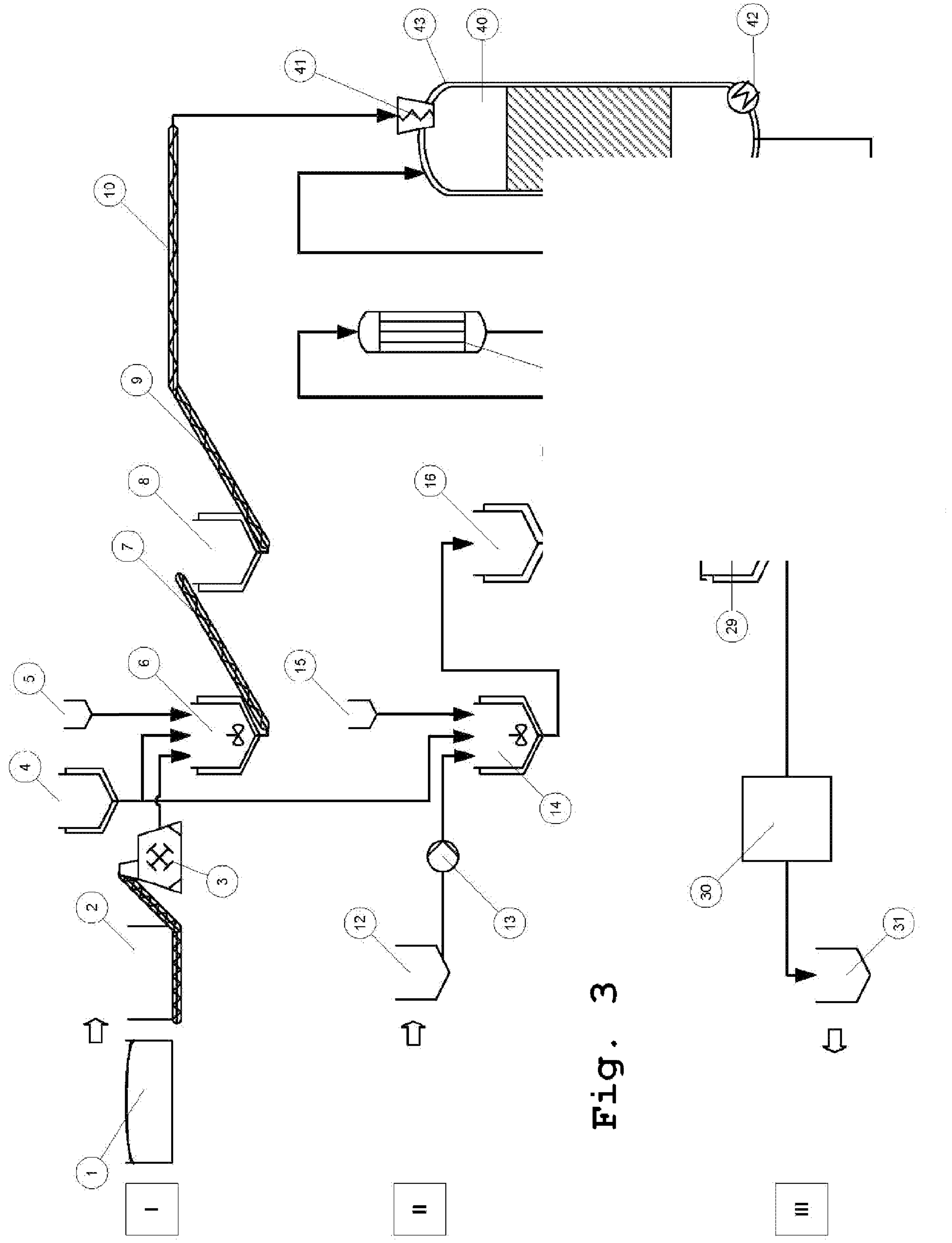

Fig. 3