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(54) **METHOD FOR PROCESSING COMBUSTIBLE CARBON-CONTAINING AND/OR
HYDROCARBON-CONTAINING PRODUCTS, REACTOR FOR IMPLEMENTING SAME
(VARIANTS) AND APPARATUS FOR PROCESSING COMBUSTIBLE CARBON-CONTAINING
AND/OR HYDROCARBON-CONTAINING PRODUCTS**

(57) The inventions are related to industrial processing of combustible carbon- and hydrocarbon products. A method of processing combustible carbon- and hydrocarbon products is implemented using a reactor equipped with temperature sensors. The reactors comprise the phases of heating the charge (13), pyrolysis of combustible components and coking (12), combustion (11), and formation of a solid residue (4). At the phases of heating the charge (13) and coking and pyrolysis (12), an aerosol sorption zone (21) is formed, i.e. dust particles and condensed liquid droplets carried away from the combustion zone (11), by flushing the upper part of the charge by liquid hydrocarbon-containing products through the dispenser (22) and/or by adding to the charge the solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C. The plant includes a reactor (either of the two aforementioned models), the discharge assembly for discharging of solid and non-combustible by-products (27), the steam-gas mixture discharge unit (28), a cyclone separator for coarse filtering (cleaning unit for purification

and removing the solid and liquid carbonaceous particles) (29), liquid products condensation unit (30), Florence flasks for condensates (31), and liquid hydrocarbon waste tank sump (32). Between the cyclone-type cleaning unit for purification and removing the solid and liquid carbonaceous particles (29) and the liquid products condensation unit (30), there is an additional steam-gas mixture purification unit (33), consisting of a centrifugal separator for fine purification (34) and one selective-type cyclone (35). The liquid hydrocarbon waste tank (32) is equipped with a feed dispenser for their charging to the dispenser (22) located at the upper lid of the reactor (3). The invention allows an improvement of the quality of purification of the steam-gas mixture from solid and liquid-drop impurities up to 95%, increases the process productivity and simplifies the required hardware design. The invention improves the quality of the steam-gas mixture purification from solid and liquid-drop impurities for up to 95 percent, increases the process productivity and simplifies the hardware design. 4 independent claims, 16 dependent claims, 4 figures, 3 tables, 3 examples.

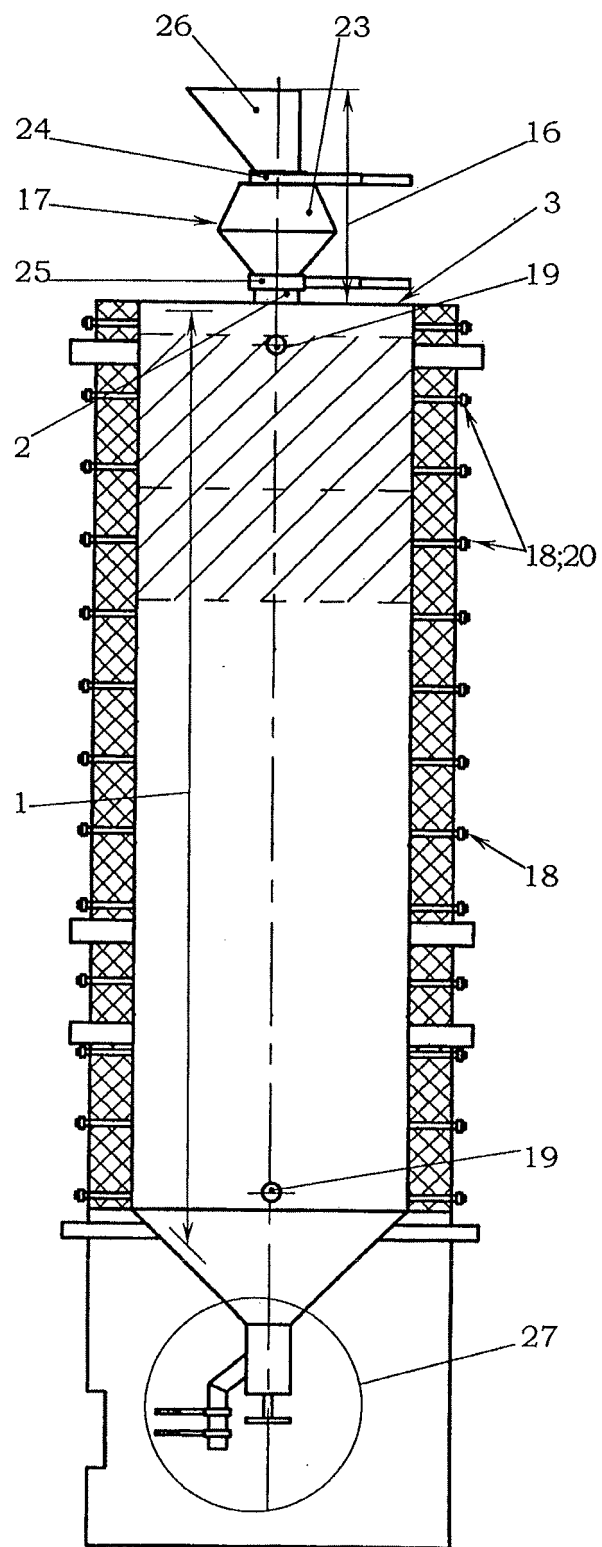


Fig. 1

Description

[0001] The inventions are related to industrial processing of combustible carbon- and hydrocarbon products and can be used, in particular, for processing the variety of manmade and household waste, processing of low grade fossil fuels, such as lignite, oil shale and the like.

[0002] The problem of processing of different types of low grade fossil fuels, domestic and industrial waste, including carbon and hydrocarbon components, is very acute. A variety of methods were developed in order to decompose the carbon and hydrocarbon products into components. However, in the course of transition from the laboratory to industrial installations, significant amounts of solids of different levels of dispersion appear in the product, which makes the quality of the steam-gas mixture (aerosol spray) inappropriate for further use, and cleaning costs are economically unjustified. This is one of the major constraints of industrial processing of low grade fossil fuels, as well as carbon and hydrocarbon waste.

[0003] There is a method for processing the solid wastes by gasification, implemented in a refractory equipped with a firebrick lining with a length of 1,600 mm and an inner diameter of 250 mm. Oxygen-containing gasifying agent is delivered into the vertical shaft furnace by counterflow, and waste (typically mixed with lump fuel) is sequentially delivered into the heating and drying zone, pyrolysis zone, combustion (oxidation) zone and cooling zone, and the process is carried out batchwise, so waste loading and unloading of solid products of processing is performed after reactor shutdown [For detailed description of the invention, see Russian patent No. 2079051, published on June 23, 1994, MPK⁶ F23G 5/027, published on May 10, 1997.] The product gas is delivered for further use, which may include further purification and burning the gas for heating (for example, heating a steam boiler). As the result, an effective recycling of solid waste is provided, including low-heating-value ones, without the use of additional energy sources and environmentally acceptable products (after appropriate purification).

[0004] The disadvantage of this method is the impossibility of its use for industrial waste treatment, insufficient cleaning quality of the product gas, which complicates further processing.

[0005] There is a method for processing the condensed fuels, which is a modification of the method, described in the Russian patent No. 2079051. A furnace charge is loaded into the reactor, which consists of the combustible component and the lump solid non-combustible material, then the gas flow is provided through this load with the supply of the gasifying agent with oxygen, water vapor or steam and the carbon dioxide, and the processing products are discharged from the reactor. The aforementioned load is sequentially delivered into the heating zone, pyrolysis zone, coking, gasification, and cooling zones, and the solid products are discharged from the reactor, and at least a fraction of the gaseous products are burned, at that, the gasifying agent used is the combustion (flue) gas mixed with the air and vapor or steam, and the process control is carried out by changing the fraction of the flue gas in the gasifying agent [For detailed description of the invention, see Russian patent No. 2152561, published on January 22, 1998, MPK⁷ F23G 5/027, published on July 10, 2000.] The product gas collected in the upper part of the reactor is directed to the gas cleaning device. As the result, processing of the condensed fuels with high energy efficiency, a high yield of valuable products, including pyrolysis resin and combustible gas, are achieved.

[0006] The disadvantages of this method include the excess amount of chemically unbound carbon in the solid residue at the outlet of the reactor, a high content of water, carbon dioxide and acid components in the product gas, which reduce the efficiency of its further use, as well as its low calorific value.

[0007] There is a method for processing the waste tires, comprising thermal decomposition of the said tires to form the vapor or steam gases and solid carbonaceous residue, their separation into the liquid and vapor or steam phases, and the solid carbon residue, separation of the liquid phase into light and heavy fractions, carbon residue chopping, granulating the carbon residue by using the wetting fluid, carbonization of carbon residue, and the gases and light resin, which are formed in the course of this process gases, are fed to the combustion furnaces of the reactor, carbonator and activator [For detailed description of the invention, see Russian patent No. 2142357, published on July 3, 1998, MPK⁶. B29B 17/00, C10G 1/10, C08J 11/02, published on December 10, 1999.] Steam gases are pumped through hot cyclones, where they are purified from dispersed carbon, and scrubber, where they are flushed with the pyrolysis resin, and a liquid phase is condensed from the steam gases, which flows into the tank sump. Clarified pyrolysis resin flows through a cyclone for irrigation in the scrubber, and the excessive resin flows into the tank sump. The carbon black resin suspension is collected at the bottom of the sump, followed by recycling in the reactor, and its hydrocarbon portion is vaporized and forwarded to the condensation system together with the volatile products, and the dispersed carbon passes forms a residue. This method reduces the volume and range of emissions resulting from the recycling of waste tires, but this comes at the expense of a serious complication of the process and increases its duration.

[0008] There is a method of environmentally friendly recycling of the oil waste, sludge and other waste containing heavy hydrocarbons, including liquid ones [For detailed description of the invention, see Russian patent No. 2116570, published on September 25, 1996, MPK⁶ F23G 7/00, F23G 7/05, published on July 27, 1998.] The separated hydrocarbons are generally free of solids and are typically composed of lighter fractions than the initial waste hydrocarbons.

[0009] The disadvantage of this method is the large amount of liquid-drop and solid impurities in the processed product,

and with as the size of these impurities reduces, their retrieval becomes more difficult or even impossible.

[0010] Judging by the whole set of essential features, the closest one to the said method for processing the carbonaceous fuels and hydrocarbon waste is the industrial method of their high temperature treatment by layers in a reactor with an effective volume of 18 cu m, the functional diameter of 1,500 mm and the active height of 10,000 mm, with the presence of the nozzle when applying oxygen agent and water vapor or steam. This technology includes the oxidation, carbonization and pyrolysis of the combustible components, forming the steam-gas mixture and solid residue, and their cooling, separation and discharge from the working chamber of the reactor; at that, a zone for synthesis and hydrogenation of hydrocarbons is provided behind the coking and pyrolysis zone, chemically unbounded carbon is separated in the coking and pyrolysis zone, and this carbon is treated with water vapor or steam in the combustion zone with the emission of free hydrogen, which is fed into the synthesis and hydrogenation zone, consistently performing synthesis and hydrogenation of hydrocarbons [For detailed description of the invention, see Russian patent No. 2385343, published on December 10, 2008, MPK C10B 49/02, F23G 5/027, published on March 27, 2010 (bulletin No. 9).]

[0011] The disadvantage of this method is the poor quality of cleaning gas mixture limiting its further use, and quality cleaning implies disproportionate costs, making it ineffective.

[0012] The problem solved by the first invention of the group and the achieved technical result comprise development of the new environmentally friendly method of industrial processing of combustible carbon and hydrocarbon products, improving the quality of purification of the steam-gas mixture from solid and liquid-drop impurities, increasing the process productivity and simplifying the required hardware design.

[0013] To solve the problem and achieve the claimed technical result, the process of processing of combustible carbon and/or hydrocarbon products is implemented, which includes preparation of a charge or batch of processed products and their sequential processing by layers in a reactor with the presence of a nozzle when applying an oxygen agent and water vapor or steam, and comprises the phases of heating the charge, pyrolysis of combustible components, coking, combustion, formation of a solid residue which is discharged from a working chamber of the reactor, formation of a steam-gas mixture (aerosol), which includes carbon particles, cooling the steam-gas mixture with the deposition of solid and liquid particles and its discharge from the working chamber of the reactor. At the phases of heating the charge and coking and pyrolysis, an aerosol sorption zone is formed by, at a minimum, flushing the upper part of the charge by liquid hydrocarbon-containing products and/or by adding to the charge or batch solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C.

[0014] In addition:

- the weight ratio of liquid hydrocarbon-containing products used for flushing the upper part of the charge to the solid original hydrocarbon-containing products in the composition of the charge amounts to (1-3):10;
- the weight ratio of added solid hydrocarbon-containing products to the original hydrocarbon-containing products in the composition of the charge amounts to (2-5):10;
- the weight ratio of liquid hydrocarbon-containing products used for flushing the upper part of the charge to the added solid hydrocarbon-containing products and original hydrocarbon-containing products in the composition of the charge or batch amounts to (1-3):(12-15);
- the centrifugal force is applied to the steam-gas mixture at the outlet of the reactor;
- the nozzle consists of the limestone with grain size ranging from 10 to 80 mm;
- in addition, the nozzle contains chemically unbounded carbon;
- the nozzle contains the pelletized fly ash containing chemically unbounded carbon;
- the rings made from heat-resistant steel are used as a fitting;
- at a minimum, waste oil and/or organic (upper) layer oil sludges and/or liquid asphalts are used as the liquid hydrocarbon-containing products;
- at a minimum, solid oil refinery waste is used as the added solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C.

[0015] There is a reactor for recycling of combustible carbon and hydrocarbon-containing waste, which design is presented in the form of layout of the semi-continuously or continuously operating device for environmentally friendly recycling of oil waste or sludge and other waste [For detailed description of the invention, see Russian patent No. 2116570], which includes the sealed operating chamber equipped with the appropriate control and measurement instrumentation, which includes the following operating zones, arranged in the technological sequence: zone for discharging the solid residues of the processing with the discharge window, air and water vapor or steam supply zone, air and water vapor or steam heating zone, combustion, coking, pyrolysis, waste heating zones, zone for separating the steam-gas products with at least one separation channel, and zone for waste loading with the gate chamber or gateway, and each zone is equipped with a temperature sensor, and the channels for air supply and separation of steam-gas products are equipped with pressure sensors.

[0016] This device has the same disadvantages as the technology implemented by means of it: namely, the large quantities of solid and liquid-drop impurities are present in the processed products, including their fine fractions, which discharge and removal makes the equipment unusable in a relatively short period of time.

[0017] Judging by the whole set of essential features, the closest one to the said device - the reactor used for processing the carbonaceous fuels and hydrocarbon waste, is the industrial reactor which includes the sealed operating chamber which has the following operating zones, located in the technological sequence: zone for discharging the solid residues of the processing with the discharge window, air and water vapor or steam supply zone with the appropriate channels, air and water vapor or steam heating zone, combustion, coking, pyrolysis zones, zone for synthesis and hydrogenation of hydrocarbons, processed products heating zone, zone for separating the steam-gas products with at least one separation channel, and zone for processed products loading with the gate chamber or gateway, and each zone is equipped with the temperature or pressure sensors [For detailed description of the invention, see Russian patent No. 2385343].

[0018] Insufficient quality of purification of the steam-gas mixture, limiting its further processing in order to separate the individual components, should be classified as one of the shortcomings of this reactor.

[0019] The problem solved by the second and third inventions of the group and the achieved technical results are the following: development of new reactor designs for environmentally friendly industrial processing of combustible carbon and hydrocarbon products, improving the quality of the steam-gas mixture purification from solid and liquid-drop impurities, increasing the equipment productivity and simplifying the required hardware design.

[0020] To solve the said problem and achieve the claimed technical result, the first version of the reactor for continuous processing of combustible carbon- and/or hydrocarbon products includes a sealed operating chamber with a feed opening in the upper lid and the following operating zones, arranged in the technological sequence: zone for discharging solid residues from the processing with a discharging window, air and/or oxygen and water vapor or steam supply zone with appropriate channels, air and/or oxygen heating zone, combustion, coking and pyrolysis zones, zone for heating the processed products, zone for separating the steam-gas mixture with at least one processed products discharge or separation channel, and a processing product loading zone with a gate chamber or gateway, and each zone of the operating chamber is equipped with at least one temperature sensor, and the zone for heating the air and/or oxygen and the steam-gas mixture separation zone are equipped with pressure sensors, and the operating chamber includes a sorption zone for solid and liquid carbon and/or hydrocarbon-containing particles, equipped with additional temperature sensors.

[0021] In addition:

- the sorption zone for solid and liquid carbon and/or hydrocarbon-containing particles is capable of maintaining the operating temperature of not higher than 300 °C;
- the upper part of the reactor is equipped with a device for supplying liquid hydrocarbons which provides for their uniform distribution over the cross section of the reactor;
- the gate chamber or gateway for batch or charge feeding of processed products is equipped with two sequentially arranged sealed shutters which form an intermediate hopper and which are located between a feed hopper and a feed opening in the upper lid of the reactor.

[0022] To solve the said problem and achieve the claimed technical result, the second version of the reactor for continuous processing of combustible carbon- and/or hydrocarbon products includes a sealed operating chamber with a feed opening in the upper lid and the following operating zones, arranged in the technological sequence: zone for discharging solid residues from the processing with a discharging window, air and/or oxygen and water vapor or steam supply zone with appropriate channels, air and/or oxygen heating zone, combustion, coking and pyrolysis zones, zone for heating the processed products, zone for separating the steam-gas mixture with at least one discharge or separation channel, processed products loading zone with a gate chamber or gateway, and each zone of the operating chamber is equipped with at least one temperature sensor, and the zone for heating the air and/or oxygen and the steam-gas mixture separation zone are equipped with pressure sensors, and the operating chamber includes a sorption zone for solid and liquid carbon and/or hydrocarbon-containing particles, equipped with additional temperature sensors. The upper part of the reactor is equipped with a device for supplying liquid hydrocarbons which provides for their uniform distribution over the cross section of the reactor.

[0023] In addition:

- the sorption zone for solid and liquid carbon- and/or hydrocarbon-containing particles is capable of maintaining the operating temperature of not higher than 300 °C;
- the gate chamber or gateway for batch or charge feeding of processed products is equipped with two sequentially arranged sealed shutters which form an intermediate hopper and which are located between the feed hopper and the feed opening in the upper lid of the reactor.

[0024] The standalone reactor does not represent a final step in obtaining a marketable product. For this purpose, it is embedded in the appropriate installation.

[0025] There is an apparatus for processing the condensed fuels, which includes the reactor, the feed assembly, the discharge assembly for discharging of solid and non-combustible by-products, the steam-gas mixture discharge unit, a cleaning unit for purification and removing the solid and liquid carbonaceous particles (usually a cyclone), liquid products condensation unit, Florence flasks for condensates (waters and organic fractions), and liquid hydrocarbon waste tank sump [For detailed description of the invention, see Russian patent No. 2152561.]

[0026] There is an oil sludge processing plant. Unlike the previous installation, it is equipped with at least two interconnected cyclones [For detailed description of the invention, see Russian patent No. 2229060, published on July 22, 2002, MPK⁷ F23G 7/05, published on January 27, 2004.]

[0027] Also, there is an apparatus for thermochemical conversion of solid organic materials into fuel components, which includes the reactor, the feed assembly for feeding the raw products into the feed opening in the upper lid of the reactor, the discharge assembly for discharging of solid and non-combustible by-products, the steam-gas mixture discharge unit, cyclone separator for coarse filtering (cleaning unit for purification and removing the solid and liquid carbonaceous particles), liquid products condensation unit, Florence flasks for condensates (waters and organic fractions), and liquid hydrocarbon waste tank sump [For detailed description of the invention, see Russian patent No. 2275416, published on March 28, 2005, MPK C10L 5/48, F23G 5/027, published on April 27, 2006.]

[0028] The common peculiarities of these systems include poor quality of steam-gas mixture purification, since cyclone cleaning doesn't allow for separation of the ultrafine aerosol particles suspended in a gas aerosol. The presence of aerosol in the steam-gas mixture leads to deposition of tar and carbon-black on the surfaces of the apparatus (heat exchangers, tanks), valves, fittings, control and measurement instrumentation and automatic equipment, which shortens their service life and requires unscheduled repairs.

[0029] The problem solved by the fourth invention of the group and the achieved technical results are the following: development of new installation for environmentally friendly industrial processing of combustible carbon and hydrocarbon products, improving the quality of the steam-gas mixture purification from solid and liquid-drop impurities, increasing the equipment productivity and simplifying the required hardware design.

[0030] To solve the said problem and achieve the claimed technical result, the installation for processing combustible carbon- and/or hydrocarbon products includes a reactor (either of the two aforementioned models) with a feed opening in the upper lid and a gate chamber or gateway for batch or charge feeding of processed products, a discharge assembly for discharging of solid and non-combustible by-products, a steam-gas mixture discharge unit, cyclone separator for coarse filtering (cleaning unit for purification and removing the solid and liquid carbonaceous particles), liquid products condensation unit, Florence flasks for condensates, and liquid hydrocarbon waste tank or waste tank sump. Between the cyclone-type cleaning unit for purification and removing the solid and liquid carbonaceous particles and the liquid products condensation unit, there is an additional steam-gas mixture purification unit, consisting of a centrifugal separator for fine purification and at least one selective-type cyclone, and the liquid hydrocarbon-containing waste tank or waste tank sump is equipped with a separate feed dispenser for charging the liquid hydrocarbon-containing waste to the distribution device located at the upper lid of the reactor. In addition, Florence flasks are equipped with feeding devices for charging the water and/or organic fractions into the combustion zone of the reactor.

[0031] The invention is illustrated by drawings, where:

- Fig. 1 shows a reactor for the continuous processing of combustible carbon- and/or hydrocarbon-containing products;
- Fig. 2 shows the first model of the reactor (see Fig. 1), equipped with a device for feeding liquid hydrocarbons;
- Fig. 3 is a schematic view of the reactor with its zones and key parts and nodes;
- Fig. 4 shows the installation (processing line) for the processing of combustible carbon- and/or hydrocarbon-containing products, based on either of the two reactor models (see Fig. 1 or Fig. 2.)

[0032] Method for processing the combustible carbon and/or hydrocarbon-containing products is implemented using the respective devices - two models of reactors and a special installation.

[0033] Reactor for continuous processing of combustible carbon- and / or hydrocarbon products (first version of the invention) contains a sealed operating chamber (1) with a feed opening (2) in the upper lid (3) and the following operating zones (4), arranged in the technological sequence: zone for discharging solid residues from the processing with the discharging window (5); air and/or oxygen and water vapor or steam supply zone (6) with the appropriate channels (7); zone for vapor or steam supply (8) through the channels (9); air and/or oxygen heating zone (10); combustion zone (11); coking and pyrolysis zones (12); zone for heating the processed products (13); zone for separating the steam-gas mixture (14) with at least one separating or discharge channel (15); processed products loading zone (16) with the gate chamber or gateway for batch or charge feeding of processed products (17) (feed unit), and each zone of the operating chamber (1) is equipped with at least one temperature sensor (18), and air heating zones (10) and steam-gas mixture separation zone (14) are equipped with pressure sensors (19), and the operating chamber (1) includes the sorption zone for solid

and liquid carbon and/or hydrocarbon-containing particles (21), equipped with additional temperature sensors (20), which is capable of maintaining the operating temperature of not higher than 300 °C - the boiling point of some hydrocarbons, such as solid oil refinery waste - for example, bitumen.

[0034] In case there is insufficient amount of low-boiling hydrocarbons in the sorption zone for solid and liquid carbon and/or hydrocarbon-containing particles (21), the upper part of the reactor can be equipped with an inlet (22) for external (i.e., from outside) feeding of liquid hydrocarbons (22), such as waste oils or organic layer of oil sludges, liquid asphalts, etc. which provides for their uniform distribution over the cross section of the reactor.

[0035] Gate chamber or gateway for batch or charge feeding of processed products (17) is equipped with two conventionally sealed (i.e., leak-free during operation) shutters (24) and (25), sequentially arranged to form an intermediate hopper (23), which are located between a feed hopper (26) and a feed opening (2) in the upper lid of the reactor (3). Conditional tightness implies the elimination of leakage of refined products into the atmosphere or, in case of leakage, the maximum allowable concentrations are not exceeded. Forming a slight suction pressure in the course of separation the steam-gas mixture in combination with the existing level of tightness of the gate chamber or gateway (17) suggest the absence of implying the environmental stress on the natural environment by this technology.

[0036] Reactor for continuous processing of combustible carbon- and / or hydrocarbon products (second version of the invention) includes the same elements as the first version, except that the upper part of the reactor is initially equipped with an inlet (22) for external (i.e., from outside) feeding of liquid hydrocarbons (22), which provides for their uniform distribution over the cross section of the reactor.

[0037] Installation for processing combustible carbon- and/or hydrocarbon products includes a reactor (either of the two aforementioned models), the gate chamber or gateway (17) for batch or charge feeding of processed products (feed unit) into a feed opening (2), located at the upper lid of the reactor (3), the discharge assembly for discharging of solid and non-combustible by-products (27), the gas-vapor mixture discharge unit (28), cyclone separator for coarse filtering (cleaning unit for purification and removing the solid and liquid carbonaceous particles) (29), liquid products condensation unit (30), Florence flasks (31) for condensates (waters and organic fractions), and liquid hydrocarbon waste tank or waste tank sump (32). Between the cyclone-type cleaning unit for purification and removing the solid and liquid carbonaceous particles (29) and the liquid products condensation unit (30), there is an additional steam-gas mixture purification unit (33), consisting of a centrifugal separator for fine purification (34) and at least one selective-type cyclone (35), and the liquid hydrocarbon waste tank or waste tank sump (32) is equipped with a separate feed dispenser (36) (e.g., a pump) for charging the liquid hydrocarbon waste to the dispenser located at the upper lid of the reactor (3) (for forced distribution through nozzles or self-gravity distribution, etc.)

[0038] In addition, Florence flasks (31) are equipped with the feeding devices (37) for charging the water and/or organic fractions into the combustion zone of the reactor (11).

[0039] Thus, the method for processing combustible carbon- and/or hydrocarbon products includes the preparation of the charge or batch which consists of processed products (hereinafter referred to as the "charge") and their sequential layer-by-layer processing in the reactor with the presence of the nozzle when applying oxygen agent and water vapor or steam, and includes the steps of heating the charge or batch, pyrolysis of combustible components, coking, combustion, formation of a solid residue, which is discharged from the working chamber (operating chamber 1) of the reactor, formation of steam-gas mixture (aerosol), which includes carbon particles, cooling the steam-gas mixture with the deposition of solid and liquid particles and its discharge from the working chamber (operating chamber 1) of the reactor. At the phase of heating the charge or batch and coking and pyrolysis, the aerosol sorption zone (21) is formed by, at a minimum, flushing the upper part of the charge or batch by liquid hydrocarbon-containing products and/or by adding to the batch or charge the solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C.

[0040] The weight ratio of liquid hydrocarbon-containing products used for flushing the upper part of the charge or batch to the solid original hydrocarbon-containing products in the composition of the charge or batch amounts to (1-3):10, and weight ratio of added solid hydrocarbon-containing products to the original hydrocarbon-containing products in the composition of the charge or batch amounts to (2-5):10, with the weight ratio of liquid hydrocarbon-containing products used for flushing the upper part of the charge or batch to the added solid hydrocarbon-containing products and original hydrocarbon-containing products in the composition of the charge or batch amounting to (1-3):(12-15). The centrifugal force is applied to the steam-gas mixture at the outlet of the reactor (28) at the nodes (29) and (33) for removal of solid and liquid carbonaceous particles.

[0041] The nozzle consists of the limestone with grain size ranging from 10 to 80 mm. In addition, the nozzle contains chemically unbounded carbon; in particular, the nozzle contains the pelletized fly ash containing chemically unbounded carbon, or the rings made from heat-resistant steel are used as a fitting.

[0042] At a minimum, waste oil and/or organic (upper) layer oil sludges and/or liquid asphalts are used as the liquid hydrocarbon-containing products, and, at a minimum, solid oil refinery waste is used as the added solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C.

[0043] Now we'll analyze the key features of the inventions.

[0044] Analysis of the different methods of processing the hydrocarbon-containing waste of gas purification methods showed that aerosols are present in the steam-gas mixture at the outlet of reactors.

[0045] In particular, Russian patents No. 2062284, published on June 23, 1994, No. MPK6 C10B 49/04, C10B 57/04, F23G 5/027, published on June 20, 1996 ("Method for processing the combustible waste such as waste tires or similar waste rubber"), and No. 2116570, published on September 25, 1996, and No. MPK6 F23G 7/00, F23G 7/05, published on July 27, 1998 ("Method for processing waste containing hydrocarbons") define aerosols in the composition of the steam-gas mixture as liquid in drops only, assuming that the solid particles are filtered out in a layer of the processed products and fitting (nozzle). Accordingly, the product gas contains only droplets of condensed hydrocarbons.

[0046] In other cases, the particles of the carbon within the steam-gas mixture are mentioned only when they have a clear positive or negative effect.

[0047] For instance, when the products are processed in the gasifier for thermal processing of carbonaceous wastes by means of method described in Russian patent No. 2342598, published on February 27, 2007, and No. MPK F23G 5/027, F23G 5/32, published on December 27, 2008 ("Gasifier for thermal processing of carbonaceous wastes and method for their processing"), the carbonized particles are thrown against the walls of the channel by centrifugal force, formation constantly regenerating skull layer, which acts as a thermal insulation and a protective layer against mechanical abrasion of the walls of the screw channel.

[0048] According to Russian patents No. 2015158, published on April 2, 1990 and No. MPK5 C10K 1/30, B01D 53/34, B01D 53/36, published on June 30, 1994 ("Method for purification of the contaminated fuel gas"), presence of carbon particles in the steam-gas mixture deactivates the catalyst, which is replaced with an equivalent amount of fresh or regenerated catalyst.

[0049] These solutions cannot be used because of the complexity of their implementation and economic unviability.

[0050] According to this invention, the main objective of the continuous industrial processing of combustible carbon- and/or hydrocarbon-containing products is obtaining a steam-gas mixture, purified from solid and liquid-drop impurities. Moreover, any possible following "traditional" purification of the steam-gas mixture should be rejected and disregarded as obviously inefficient, ineffective and leading to deposition of tar and carbon-black on the surfaces of the apparatus, valves, fittings, control and measurement instrumentation and automatic equipment.

[0051] In case the method of continuous processing of combustible carbon- and/or hydrocarbon products is applied, an aerosol (dust particles, including the carbon-black and condensed liquid droplets carried away from the combustion zone (11) and generated by friction of moving layers of the charge or batch) sorption zone (21) is formed at the stage of heating the charge or batch, coking and pyrolysis by, at a minimum, flushing the upper part of the charge or batch by liquid hydrocarbon-containing products and/or by adding to the batch or charge the solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C. Implementing this method allows to entrap in the reactor the large - up to 95% - proportion of the carbon-, hydrocarbon-containing and powdered solid and liquid-drop impurities which are subsequently oxidized in the combustion zone (11), and the steam-gas mixture obtained at the reactor outlet will be practically suitable for subsequent processing, including chemical processing (e.g., for obtaining the individual pure substances).

[0052] Professional literature doesn't shed much light on the sorption mechanism. Most likely, one may suggest that the processes of physical and chemical absorption and adsorption take place simultaneously.

[0053] The weight ratio of liquid hydrocarbon-containing products used for flushing the upper part of the charge or batch to the solid original hydrocarbon-containing products in the composition of the charge or batch should be equal to (1-3):10. If the quantity of hydrocarbon-containing products differs from the above ratio, it leads to insufficient quality of purification of the steam-gas mixture or to unnecessary expenditure of liquid hydrocarbon products, although, for example, in case of their conscious processing it can be justified. However, then this technology should be implemented by means of special processing methods. The same applies to the weight ratio of added solid hydrocarbon-containing products to the original hydrocarbon-containing products in the composition of the charge or batch, which should be equal to (2-5):10.

[0054] The same approach should also be taken into account in the course of flushing the upper part of the charge or batch with the liquid hydrocarbon-containing products. Composition of the charge or batch includes added solid hydrocarbon-containing products and original hydrocarbon-containing products, which weight ratio should be equal to (1-3):(12-15). Any deviations from these limits result in a serious shift of the calculated boundaries of the sorption zone (21).

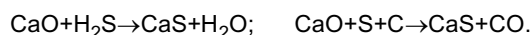
[0055] At a minimum, waste oil and/or organic (upper) layer oil sludges and/or liquid asphalts are used as the liquid hydrocarbon-containing products, and, at a minimum, solid oil refinery waste, such as bitumen, petroleum pitches, cracking residues, solid pyrolysis residues and others, is used as the added solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C. These products are mostly various waste products and their processing into the construction materials is not always justified.

[0056] The mechanism of reducing the amount of aerosol in the outgoing steam-gas mixture can be explained as follows. When the charge or batch is flushed by liquid hydrocarbon-containing products, or when their solid analogues are melted, a liquid film is formed on the charge or batch, sorbing liquid or solid aerosol particles and delivering them

into the coking and combustion zones (12).

[0057] The centrifugal force is applied to the steam-gas mixture, purified in the reactor, at the nodes (29) and (33), which allows to separate the finest particles of mechanical impurities due to the increase of their kinetic energy, and quite often the power of cyclone equipment assembly (29), which is used to settle the particles larger than 25 microns, is insufficient - the process requires the fine centrifugal separation of the node (33) using the separator (34), which allows to separate particles with sizes of 5-25 microns, which flow into selective-type cyclones (35) after consolidation. Next, they flow into the common reservoir (38).

[0058] A fitting (nozzle) is used to ensure the gas tightness of the charge or batch being processed. A limestone with grain size ranging from 10 to 80 mm can be used for the nozzle. As a result, the reactor will function as a kiln, and a powder of calcium oxide will be present at the outlet, which can be directly used for production of mixes and mortars, and the sulfur content in the steam-gas mixture will be reduced as a result of the following reactions:



[0059] The range of nozzles used can be extended through the use of those nozzles that contain chemically unbounded carbon. A graphic example of such nozzles is the nozzle made of pelletized fly ash containing chemically unbounded carbon. Such carbon is burned in the reactor and decarburized nozzle becomes the raw material for producing, for example, high-quality cement. In addition, Raschig rings made of heat-resistant steel and having a large free volume can be used as a fitting for the processing of high-ash products.

[0060] Features of reactors used for the continuous processing of combustible carbon- and/or hydrocarbon-containing products include special zones formed in the operating chambers, which are capable of maintain an operating temperature no higher than 300 °C - sorption zone for solid and liquid carbon- and/or hydrocarbon-containing particles (21), which are equipped with additional temperature sensors (20) for managing the processing and cleaning of impurities from the steam-gas mixture. This zone (21) is formed as a result of softening of hydrocarbon-containing products, intentionally added to the composition of the charge or batch, having a softening point above 60 °C, such as bitumen, petroleum pitches, cracking residues, solid pyrolysis residues and others. Actually, processed products and fitting (nozzle), being "wetted" by low-melting hydrocarbons, are able to adsorb a variety of related impurities on their surfaces - both solid (dust, carbon-black) and liquid (liquid-drop organic compounds). Selection of low-melting hydrocarbons added to the charge or batch composition introduces a new functionality to the zones previously used only for heating, coking and pyrolysis of the charge or batch (13) and (12): it allows to use it as an effective "wet" filter - the sorption zone (21).

[0061] Formation of such a zone (21) was made possible only by using the reactors for industrial processing of combustible carbon- and/or hydrocarbon products. Here rather than elsewhere, in the zones of heating, coking and pyrolysis - (13) and (12) - due to the need to heat up large volumes of processed products, continuously fed through a gate chamber or gateway (17) and passing through them the steam-gas mixture in order to cool it, there was a need to increase the size of the zones (13) and (12).

[0062] The feature that has always been considered a shortcoming of compact, light-duty reactors and batch or charge reactors, i.e. reactors belonging to the so-called "laboratory" class, as well as reactors used for processing of carbon- and/or hydrocarbon-containing products having stable chemical composition, which was leading to reduction of their effective volume and increase of their dimensions, has led to an unexpected positive effect in the context of this invention - it allows to clean the steam-gas mixture from the larger amount of impurities (dust particles, carbon-black, liquid-drop hydrocarbons).

[0063] In case the amount of low-melting hydrocarbons in the charge or batch is insufficient for the formation of the sorption zone (21), the upper part of the reactor is equipped with an inlet (22) for external feeding of liquid hydrocarbons (22), which provides for their uniform distribution over the cross section of the reactor and for additional flushing of the charge or batch through its nozzles, perforated tubes and the like.

[0064] Accordingly, if the "clean" charge or batch is used, it is possible to flush it using only liquid hydrocarbon-containing products - not only for the formation of the sorption zone (21) as a part of the reactor, but also for their targeted processing in the charge or batch - this is a difference between two versions of the reactors.

[0065] Given that the processing of carbon- and/or hydrocarbon products involves a possible release of processed products into the atmosphere, the gate chamber or gateway for batch or charge feeding of processed products (17) is equipped with two conventionally sealed shutters (24) and (25), sequentially arranged to form an intermediate hopper (23), which are located between the feed hopper (26) and the feed opening (2) in the upper lid of the reactor (3). A slight suction pressure (500-5,000 Pa) may be observed in the upper part of the reactor. This tightness is sufficient to ensure the environmental safety of the process.

[0066] Of course, use of any of the reactors can significantly reduce the amount of impurities in the steam-gas mixture composition. However, the greatest effect is obtained by use of the installation, which includes at least one of the above-mentioned reactors.

[0067] Using the installation for processing combustible carbon- and/or hydrocarbon products, comprising the aforementioned reactors, implies that between the cyclone-type cleaning unit for purification and removing the solid and liquid carbonaceous particles (29) and the liquid products condensation unit (30), there is an additional steam-gas mixture purification unit (33), consisting of a centrifugal separator for fine purification (34) and at least one selective-type cyclone (35). Such combination of a treatment equipment has not been used before, because traditional installations separated from the steam-gas mixture the impurities which were entrapped in the sorption zones (21) of the two above-mentioned reactors. Thus, those liquid hydrocarbon-containing waste that flows into the appropriate reservoir (38), may be forwarded to the dispenser (22) located at the upper lid of the reactor (3) for the flushing of charge or batch - either alone or in addition to "external" liquid hydrocarbon-containing products from the waste tank sump (32), fed into the same area in order to create a sorption zone (21).

[0068] Water and/or the organic fraction from the Florence flasks (31) is partially fed into the combustion zone of the reactor (11) via the channels (9), originally designed for steam supply, and partially - for further processing.

[0069] At the outlet used for discharge of the steam-gas mixture from the liquid products condensation unit (30), a backup node used for additional purification of the steam-gas mixture (39) may be set up, which is structurally similar to the node (33). Using this node is capable of bringing the quality of purification of the mixture in approximate accordance with the sanitary standards.

[0070] To illustrate the implementation of the invention, let's consider the following examples.

Example 1. Coal waste (briquettes with the thickness of 40 mm and height of 40 mm) should be reprocessed.

[0071] Composition of coal briquettes, wt%:

- Humidity - 20;
- Ash content on a dry weight basis - 60;
- Volatile matter content on a dry weight basis - 15.

[0072] Elemental composition of the combustible mass, wt%:

C - 86.8; H - 5.8; O - 5.6; N - 1.7; S - 0.7.

[0073] Installation capacity (raw product) - 1,600 kg/hour

[0074] Rings (32x32x3) made from heat-resistant steel (20X23H18) are used as a fitting/nozzle - 1,000 kg/hour.

[0075] Gasifying agents supplied:

- superheated water vapor or steam ($T=250^{\circ}\text{C}$, $P=1.4\text{ MPa}$, decomposition level 50%) - 350 kg/hour
- air - 1,733 kg/hour ($1,343\text{ nm}^3/\text{hour}$).

[0076] To bind the sulfur, CaCO_3 in the form of pieces with linear sizes of 10-80 mm is fed at the rate of 35 kg/hour.

[0077] To form the sorption zone (21), the oily waste is fed at the rate of 200 kg/hour and the off-spec bitumen is supplied at the rate of 400 kg/hour. (This solves the problem of disposal of waste oils and bitumen).

[0078] Temperature in the combustion zone (11) does not exceed $1,100^{\circ}\text{C}$.

[0079] The outflow at the outlet of the reactor (28) equaled to 1,819 kg/hour and was characterized by the following structure (kg/hour):

nozzle - 1,000; ash - 768; carbon-containing products - 30;
CaS - 6.3; CaO - 15.

[0080] According to the chromatographic analysis of the condensed products performed with "Crystalluxs-4000M" chromatograph and KR-1459 gas analyzer, the outflow at the outlet of the reactor amounted to 3,491 kg/hour and was characterized by the following structure (kg/hour):

water - 517;	benzene - 12.6;
carbon dioxide - 26.6;	carbon monoxide - 997.6;
hydrogen - 79;	methane - 105;
ammonia - 2;	$\text{C}_4\text{-C}_8$ fractions - 125;
$\text{C}_9\text{-C}_{12}$ fractions - 120;	fractions $> \text{C}_{12}$ - 60;

(continued)

phenol-containing agents - 99; hydrogen sulfide - 0.8.

[0081] The content of solid and liquid-drop impurities was measured by transmitting a part of a gas stream by a compressor (1-6 l/min) through a cooler and fibrous filter. According to the weight difference of clean and contaminated filter and volume of the transmitted gas, the content of the particles was determined. Gas offtake for analysis of solid and liquid-drop impurities was carried at the outlet of the reactor, after treatment performed using the 900-mm cyclone (29), newly installed centrifugal separator (33), and a backup centrifugal separator (39).

[0082] The obtained results showing the efficiency of purifying the steam-gas mixture were summarized in Table 1.

Example 2 (comparative).

[0083] As in the previous example, coal waste (briquettes with the thickness of 40 mm and height of 40 mm) should be reprocessed. Composition of coal briquettes and elemental composition of the combustible mass, quantity of briquettes, amount of calcium carbonate are the same as in Example 1. The difference lies in the absence of the sorption zone, since no liquid hydrocarbons like the oily waste and the off-spec bitumen are fed.

[0084] Gasifying agents supplied:

- superheated water vapor or steam ($T=250\text{ }^{\circ}\text{C}$, $P=1.4\text{ MPa}$, decomposition level 50%) - 200 kg/hour;
- air- 1,356 kg/hour.

[0085] Temperature in the combustion zone does not exceed $1,100\text{ }^{\circ}\text{C}$.

[0086] The outflow at the outlet of the reactor equaled to 1,809 kg/hour and was characterized by the following structure (kg/hour):

nozzle - 1,000; ash - 768; carbon-containing products - 20;
CaS - 6.3; CaO - 15.

[0087] According to the chromatographic analysis of the condensed products performed with "Crystalluxs-4000M" chromatograph and KR-1459 gas analyzer, the outflow at the outlet of the reactor amounted to 2,382 kg/hour and was characterized by the following structure (kg/hour):

water - 442; benzene - 12.6;
carbon dioxide - 26.6; carbon monoxide - 728.6;
hydrogen - 25.5; methane - 50.5;
ammonia - 2.9; phenol-containing agents - 99;
hydrogen sulfide - 0.8; nitrogen - 1,044.

[0088] The content of solid and liquid-drop impurities was measured by transmitting a part of a gas stream by a compressor (1-6 l/min) through a cooler and fibrous filter. According to the weight difference of clean and contaminated filter and volume of the transmitted gas, the content of the particles was determined. Gas offtake for analysis of solid and liquid-drop impurities was carried at the outlet of the reactor, after treatment performed using the 900-mm cyclone (27), newly installed centrifugal separator (33), and a backup centrifugal separator (39).

[0089] The obtained results showing the efficiency of purifying the steam-gas mixture were summarized in Table 2.

Example 3. Carbon-containing raw product - the coke produced during coking slightly metamorphosed coals with the reduced caking capacity (i.e. coke not used for metal smelting) - should be processed.

[0090] Qualitative characteristics of coke, wt%:

- humidity, W^r - 8;
- ash content, A^d - 14;
- volatile matter content, V^{daf} - 2.

[0091] Elemental composition of the combustible mass, wt%:

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C-96; H-0.8; N-1.0; S-1.4; O-0.8.

Average size - 40

Capacity (bulk coke) - 1,000 kg/hour.

[0092] Rings (32x32x3) made from heat-resistant steel (20X23H18) are used as a fitting/nozzle - 300 kg/hour.

[0093] Gasifying agents supplied:

- superheated water vapor or steam (T=250 °C, P =1.4 MPa, decomposition level 50%) - 800 kg/hour;
- Bulk oxygen with a nitrogen content of 5% - 678 kg/hour.

[0094] To bind the sulfur, CaCO₃ in the form of pieces with linear sizes of 10-80 mm is fed at the rate of 112 kg/hour.

[0095] To form the sorption zone (21), the oily waste is fed at the rate of 300 kg/hour.

[0096] Temperature in the combustion zone (11) does not exceed 1,200 °C.

[0097] The outflow at the outlet of the reactor (28) equaled to 525 kg/hour and was characterized by the following structure (kg/hour):

nozzle - 300; ash - 129; carbon-containing products - 30;
CaS - 14.8; CaO - 51.5;

[0098] According to the chromatographic analysis of the condensed products performed with "Crystalluxs-4000M" chromatograph and KR-1459 gas analyzer, the outflow at the outlet of the reactor amounted to 2,671 kg/hour and was characterized by the following structure (kg/hour):

water -484; carbon dioxide - 49;
carbon monoxide - 1,749; hydrogen - 77;
methane - 13; hydrogen sulfide - 4;
nitrogen - 40; oxygen - 6.3;
C₄-C₈ fractions -150; C₉-C₁₂ fractions - 60;
fractions > C₁₃ - 30.

[0099] The content of solid and liquid-drop impurities was measured by transmitting a part of a gas stream by a compressor (1-6 l/min) through a cooler and fibrous filter. According to the weight difference of clean and contaminated filter and volume of the transmitted gas, the content of the particles was determined. Gas offtake for analysis of solid and liquid-drop impurities was carried at the outlet of the reactor, after treatment performed using the 900-mm cyclone (29), newly installed centrifugal separator (33), and a backup centrifugal separator (39).

[0100] The obtained results showing the efficiency of purifying the steam-gas mixture were summarized in Table 3.

[0101] Other combustible carbon- and/or hydrocarbon-containing products, such as tires and the like, are processed similarly to the above Examples 1-3.

[0102] Thus, technical solutions implemented on the basis of the invention, ensure the environmentally friendly industrial processing of combustible carbon- and hydrocarbon-containing products, improving the quality of purification of the steam-gas mixture from solid and liquid-drop impurities, increasing the equipment productivity and simplifying the required hardware design.

Table 1

Steam-gas mixture purification efficiency (see Example 1)	
Steam-gas mixture offtake location	Total impurity content, g/nm ³
Outlet of the reactor	0.8 - 1.2
Outlet of 900-mm cyclone	0.5 - 0.8
Outlet of the primary centrifugal separator	0.05
Outlet of the backup centrifugal separator	0.005 - 0.001

Table 2

Steam-gas mixture purification efficiency (see Example 2)	
Steam-gas mixture offtake location	Total impurity content, g/nm ³
Outlet of the reactor	20
Outlet of 900-mm cyclone	15
Outlet of the primary centrifugal separator	0.5
Outlet of the backup centrifugal separator	0.05

Table 3

Steam-gas mixture purification efficiency (see Example 3)	
Steam-gas mixture offtake location	Total impurity content, g/nm ³
Outlet of the reactor	3 - 5
Outlet of 900-mm cyclone	1 - 2
Outlet of the primary centrifugal separator	0.08 - 0.10
Outlet of the backup centrifugal separator	0.009 - 0.010

Claims

1. A method for processing the combustible carbon- and/or hydrocarbon products, which comprises preparation of a charge which consists of processed products and their sequential layer-by-layer processing in a reactor with the presence of a nozzle when applying an oxygen comprising agent and steam, and comprising the steps of: heating the charge; pyrolysis of combustible components; coking; combustion; formation of a solid residue, which is discharged from a working chamber of the reactor; formation of a steam-gas mixture, which includes carbon containing particles; cooling the steam-gas mixture with deposition of solid and liquid particles and its discharge from a working chamber of the reactor; **characterized in that** during the steps of heating the charge, coking and pyrolysis, an aerosol sorption zone is formed by at least flushing the upper part of the charge by liquid hydrocarbon-containing products and/or by adding to the charge solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C.
2. A method, according to claim 1, **characterized in that** the weight ratio of liquid hydrocarbon-containing products used for flushing the upper part of the charge to the sum of the original solid hydrocarbon-containing products in the composition of the charge is (1-3):10.
3. A method according to claim 1, **characterized in that** the weight ratio of added solid hydrocarbon-containing products to the original hydrocarbon-containing products in the composition of the charge is (2-5):10.
4. A method according to claim 1, **characterized in that** the weight ratio of liquid hydrocarbon-containing products used for flushing the upper part of the charge to the sum of solid hydrocarbon-containing products and original hydrocarbon-containing products in the composition of the charge is (1-3):(12-15).
5. A method according to claim 1, **characterized in that** a centrifugal force is applied to the steam-gas mixture at the outlet of the reactor.
6. A method according to claim 1, **characterized in that** limestone with grain size ranging from 10 to 80 mm is used as a nozzle.
7. A method according to claim 1, **characterized in that** the nozzle in addition contains chemically unbounded carbon.
8. A method according to claim 1 **characterized in that** pelletized fly ash containing chemically unbounded carbon is used as a nozzle.

9. A method according to claim 1, **characterized in that** rings made from heat-resistant steel are used as a nozzle.
10. A method according to claim 1 **characterized in that** at least waste oil and/or organic (upper) layer oil sludge and/or liquid asphalts are used as the liquid hydrocarbon-containing products.
11. A method according to claim 1 **characterized in that** at least solid oil refinery waste is used as the added solid hydrocarbon-containing products having a softening point above 60 °C and the end boiling point above 300 °C.
12. A reactor for continuous processing of combustible carbon- and/or hydrocarbon products according to the method of any one of the claims 1-11, comprising a sealed operating chamber with a feed opening in the upper lid and the following operating zones, arranged in the technological sequence: zone for discharging solid residues from the processing with a discharging window; air and/or oxygen and steam supply zone with appropriate channels; air and/or oxygen heating zone; combustion, coking and pyrolysis zones; zone for heating the processed products; zone for separating the steam-gas mixture with at least one product discharge or separating channel; and a processing product loading zone with a gateway; and each zone of the operating chamber is equipped with at least one temperature sensor, and the zone for heating the air and/or oxygen and the steam-gas mixture separation zone are equipped with pressure sensors; **characterized in that** the operating chamber includes a sorption zone for solid and liquid carbon and/or hydrocarbon-containing particles, equipped with additional temperature sensors.
13. A reactor according to claim 12, **characterized in that** the sorption zone for solid and liquid carbon and/or hydrocarbon-containing particles is capable of maintaining the operating temperature of not higher than 300 °C.
14. A reactor according to claim 12, **characterized in that** the upper part of the reactor is equipped with a device for supplying liquid hydrocarbons which provides for their uniform distribution over the cross section of the reactor.
15. A reactor according to claim 12, **characterized in that** the gateway for charge feeding of processed products is equipped with two sequentially arranged sealed shutters which form an intermediate hopper and which are located between a feed hopper and a feed opening in the upper lid of the reactor.
16. A reactor for continuous processing of combustible carbon- and/or hydrocarbon products according to any one of the claims 1-11, comprising a sealed operating chamber with a feed opening in the upper lid and the following operating zones, arranged in the technological sequence: zone for discharging solid residues from the processing with a discharging window; air and/or oxygen and steam supply zone with the appropriate channels; air and/or oxygen heating zone; combustion, coking and pyrolysis zones; zone for heating the processed products; zone for separating the steam-gas mixture with at least one discharge or separating channel; processed products loading zone with a gateway; and each zone of the operating chamber is equipped with at least one temperature sensor, and the zone for heating the air and/or oxygen and the steam-gas mixture separation zone are equipped with pressure sensors; **characterized in that** the operating chamber includes a sorption zone for solid and liquid carbon and/or hydrocarbon-containing particles, equipped with additional temperature sensors; and **in that** the upper part of the reactor is equipped with a device for supplying liquid hydrocarbons which provides for their uniform distribution over the cross section of the reactor.
17. A reactor according to claim 16, **characterized in that** the sorption zone for solid and liquid carbon- and/or hydrocarbon-containing particles is capable of maintaining the operating temperature of not higher than 300 °C.
18. A reactor according to claim 16, **characterized in that** gateway for charge feeding of processed products is equipped with two sequentially arranged sealed shutters which form an intermediate hopper and which are located between a feed hopper and a feed opening in the upper lid of the reactor.
19. A plant for processing combustible carbon- and/or hydrocarbon products, which includes a reactor according to any one of the claims 12-15 or 16-18, equipped with a feed opening in the upper lid and a gateway for charge feeding of processed products, a discharge assembly for discharging of solid and non-combustible by-products, a steam-gas mixture discharge unit, a cyclone-type cleaning unit for coarse purification by removing the solid and liquid carbonaceous particles, a liquid products condensation unit, Florence flasks for condensates, and a liquid hydrocarbon waste tank, **characterized in that** between the cyclone-type cleaning unit for purification and removing the solid and liquid carbonaceous particles and the liquid products condensation unit, there is an additional steam-gas mixture purification unit, consisting of a centrifugal separator for fine purification and at least one selective-type cyclone, and **in that** the liquid hydrocarbon-containing waste tank is equipped with a separate feed dispenser for

charging the liquid hydrocarbon-containing waste to the distribution device located at the upper lid of the reactor.

20. A plant according to claim 19, **characterized in that** the Florence flasks are equipped with a feeding device for charging the water and/or organic fractions into the combustion zone of the reactor.

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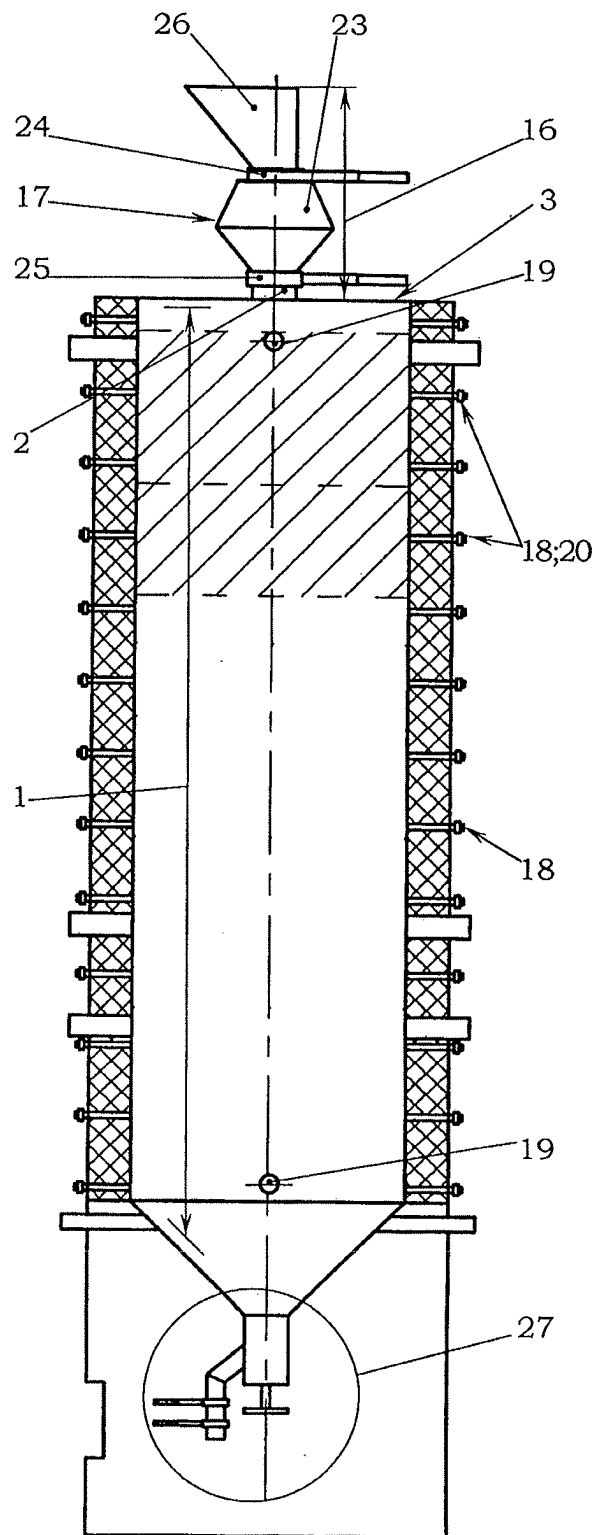


Fig. 1

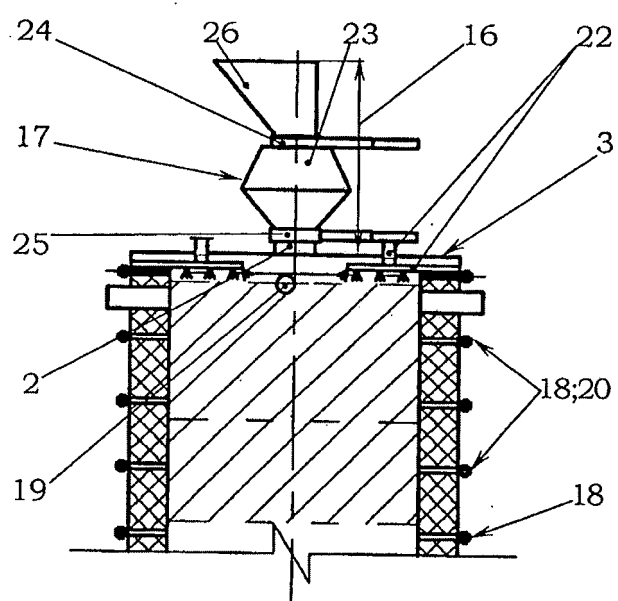


Fig. 2

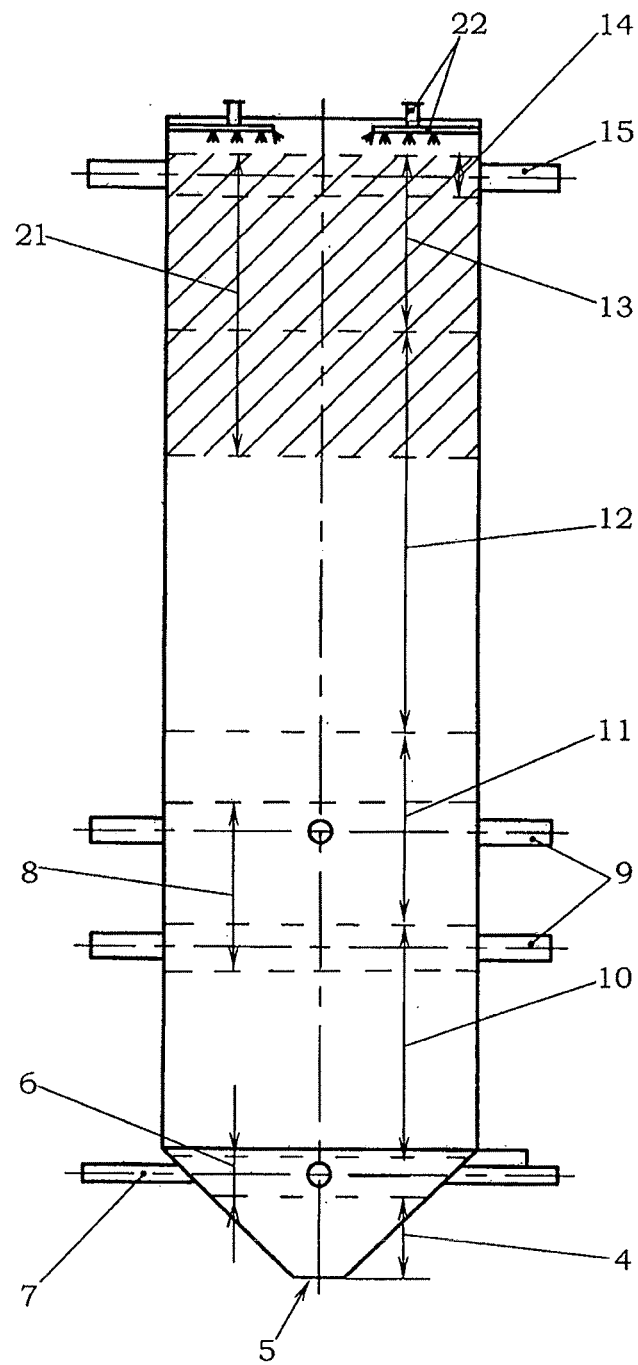


Fig. 3

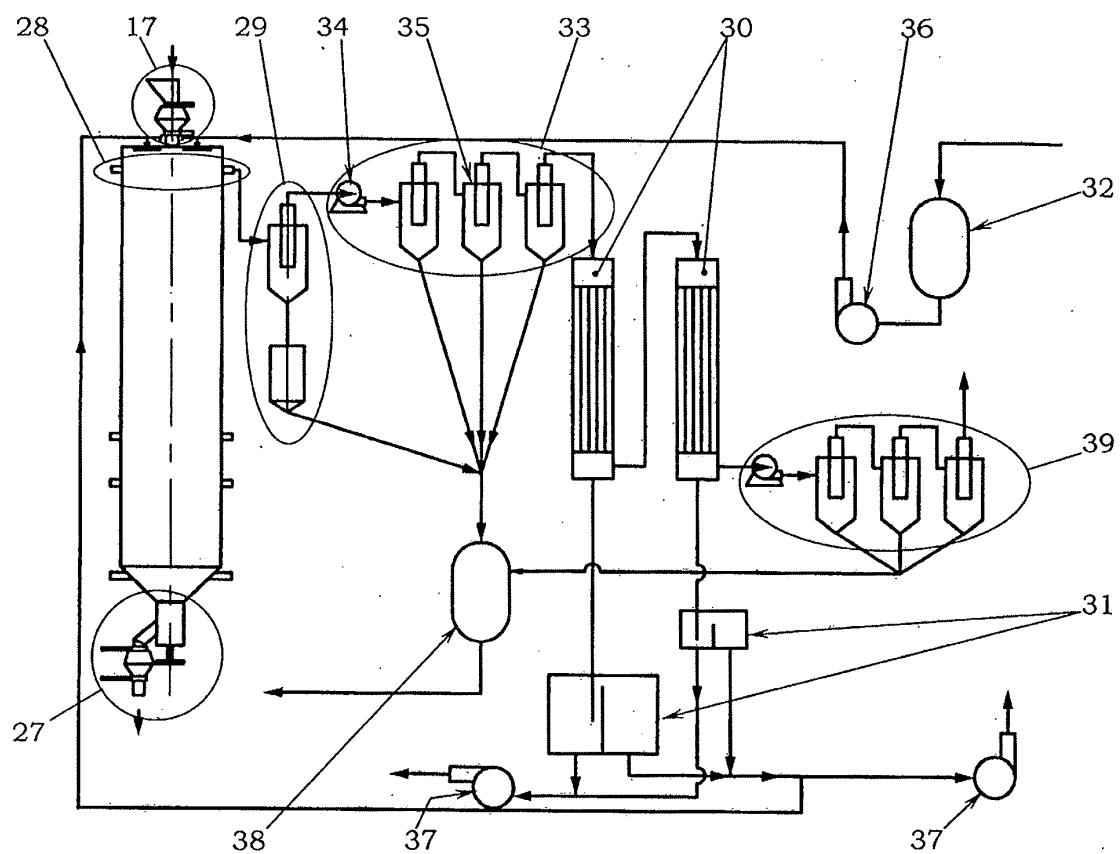


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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