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(54) **Title**: DEVICE FOR THE MULTI-STAGE GASIFICATION OF CARBONACEOUS FUELS

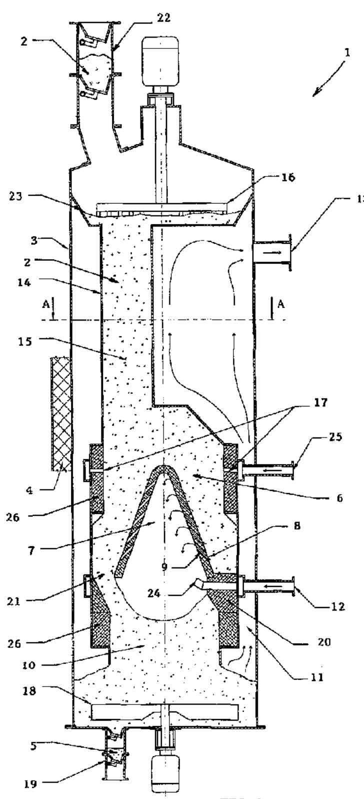

FIG.1

(57) **Abstract**: Device (1) for the multi-stage gasification of carbonaceous fuels (2), namely biomass, for the production of generator gas in cogeneration plants with a low content of tar and other impurities. Device (1) comprises a hermetically sealed vertical container (3) which is fitted with insulation (4). Inside vertical container (3) is pyrolysis chamber which is adapted for filling with carbonaceous fuel (2) from above of the container (3). Under pyrolysis chamber is in the container (3) a partial oxidation chamber (7) for oxidation of the pyrolysis product which is delimited by a refractory casing (8) and the partial oxidation chamber (7) is followed by a reduction zone (10) for chemical reduction of oxidized product gas (11). In preferably form is pyrolysis chamber embodied by at least one vertically oriented pyrolysis channel (15) and in the container (3) is arranged an integral lining (14).

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Device for the multi-stage gasification of carbonaceous fuels

Field of the invention

The invention relates to a device for the multi-stage gasification of carbonaceous fuels, namely biomass, for the production of generator gas in cogeneration plants with a low content of tar and other impurities.

Background of the invention

Biomass is considered to be a carbon-based material of plant or animal origin and a renewable source of energy. For the industrial use of biomass, the greatest importance is held by woody biomass obtained by processing tree and shrub vegetation into the form of wood chips, sawdust, briquettes, pellets, etc. Energy is extracted from plant biomass by thermal or biochemical processes, while the thermal processes include liquefaction, pyrolysis, gasification, and combustion.

Gasification is a partial oxidation process where the biomass is first burned, then the resulting flue gases are introduced to uncombusted and pyrolytically decomposed fuel, resulting in the chemical conversion of the flue gas to producer gas. Producer gas is a mixture of combustible carbon monoxide, hydrogen, tars, and lesser amounts of carbon dioxide, methane and other components.

At present, gasifier devices for smaller heat capacities from 0.5 MWt to 2 MWt with a fixed bed are used which, according to the methods used to direct the flow of fuel and gas, may be divided into countercurrent and concurrent flows. The advantage of countercurrent gasifier devices is that they have very good thermal efficiency, have minimal mechanical unburned residues, and are of simple construction, thus also representing lower investment costs. The disadvantages of the countercurrent gasifier device consist in the fact that the product gas is polluted by tar in the hundreds of g/m^3 and, through expensive and complicated methods, must be cleaned to the pollution level permitted for the production of electrical energy in gas cogeneration units, which is maximally 20 mg/m^3.

In contrast to the aforementioned, the cocurrent gasifier device can produce relatively clean product gas; with a heat output of a gasifier device above 0.5 MWt, however, the tar content in the product gas rapidly increases, resulting in the repeated necessity of expensively cleaning the tar from the product gas. The greatest disadvantage of these gasifier devices is the need to use fuel in coarser granulometry with a small proportion of fine fractions, otherwise the gasification process is uneven with large fluctuations in pressure losses.

There also exist multi-stage gasification technologies characterized by having separate zones for fuel pyrolysis, partial oxidation, and reduction of bed gas. The great advantage of these devices is a very low tar content in the product gas, so expensive cleaning of the gas from tars in the gas engine is not necessary. The gas is only stripped of solid particles (dusts) in the filter.

Such multi-stage gasifier devices may include the subject of the invention according to patent CZ 295171, which describes a three-zone biomass gasifier device. The three-zone biomass gasifier device consists of a vertically oriented construction consisting of mutually-nested inserted cylindrical containers which delimit individual zones within the gasifier device, wherein a biomass dispenser opens from above into the highest container while a revolving bed is arranged at the bottom of the lowest container. The containers have different diameters, with the highest container having the smallest diameter. The bed is designed as a horizontal rotating table top, which is equipped in its center with a perforated conical grate through which the gasifying medium flows into the container. A tray to catch the ash is arranged under the table. The disadvantages of the three-zone gasifier device consist in the fact that the biomass is processed unevenly, it must be pre-dried, and that the gasifier device is structurally demanding with high investment costs because it uses a moving bed, which is stressed and subject to faulting from the dimensional dilation due to high temperatures; furthermore the device is problematic in its discharge of product gas and capture of return gas which is achieved by testing and specific setting, as shown in the example of its execution. The gasifier device according to the invention has no pyrolysis area, and it also has insufficiently effective separation of individual work zones, since the combustion zone and reduction zone are mostly in the same space, and it is known for its poor controllability and flexibility of performance.

The task of the invention is to create a device for the multi-stage gasification of carbonaceous fuels with a very low tar content in the product gas, and which would be structurally simple, have a sufficient area for pyrolysis, a high conversion efficiency of the reduction zone, would process a large range of fuels with different granulometry, would have a well-controllable performance, would permit easy sizing of the device according to the required performance, and would provide a long service life while achieving low operating and maintenance costs.

Summary of the invention

This objective is resolved by creating a device for multi-stage gasification of carbonaceous fuels according to this submitted invention.

The device for multi-stage gasification of carbonaceous fuel includes a hermetically sealed vertical container with a pyrolysis chamber, wherein the container is insulated and is adapted for filling the container with carbonaceous fuel from the top of the container and for removing ash from the bottom of the container. The device further includes a partial oxidation chamber for the oxidation of the pyrolysis products enclosed in a refractory casing which is essentially defined by a conical, cylinder, or pyramid shape, and which is equipped with oblique air passages. The device also contains a reduction zone for the chemical reduction of oxidized product gas released from the partial oxidation chamber, wherein at least one secondary air inlet leads into the chamber and at least one outlet for product gas leads out of the vessel. The subject-matter of the invention consists in the fact that the reduction zone is arranged beneath the casing of the partial oxidation chamber inside the container, formed by a retarder for slowing the progression of carbonized pyrolysis residue of fuel through the container vertically oriented towards the reduction zone, wherein the product gas outlet is arranged beyond the reduction zone in the direction of the process of the product gas out of the device.

This is advantageous in that the casing of the partial oxidation chamber delimits a free space for the progress of oxidation of the volatile constituents, the fuel including the tars, in the partial oxidation chamber, since the pyrolysis residue of the fuel does not accumulate in the partial oxidation chamber where it would obstruct, but leads down the casing into the reduction zone. The advantage is that the product gas is forced to leave the container of the device by passing through the reduction zone where, thanks to suitable chemical physical conditions, the reduction of incombustible CO^2 to combustible CO may occur, thereby increasing the heat potential of the product gas for the cogeneration unit.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, the pyrolysis chamber is formed by at least one vertically oriented pyrolysis channel for the passage of fuel into the partial oxidation chamber, separate from the container, and between the pyrolysis channel and the container there is a space for passage of the product gas from the bottom part of the container into the upper part of the container by bypassing the pyrolysis channel into the outlet for product gas arranged in the upper part of the container. The pyrolysis channel forms a heat transfer surface thus allowing for the exchange of heat, wherein the heat from the product gas is transferred to the fuel stored in the pyrolysis channel, wherein the heat causes a pyrolytic decomposition of the fuel before the leaving the pyrolysis channel and the subsequent passage of fuel to the pyrolysis chamber.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, there is, inside the container, an integral lining arranged which forms, in the upper part of the container, a hopper opening into a set of vertical pyrolysis channels which are arranged separately from each other and from the container, and which lead together to the central part of the integral lining forming an interspace and a partial oxidation chamber with a refractory casing, and a lower portion of the integral lining forms a reduction zone, wherein between the outer casing of the integral lining and the inner wall of the container there is a space for the passage of the product gas from the reduction zone by bypassing the integral lining to the outlet. The integral lining delimits the individual active areas within the container and allows for the flow of product gas in the space between the container wall and the lining wall, thereby providing conditions for the efficient transfer of heat to the fuel in the pyrolysis channels.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, the integral lining includes nozzles of primary air, for an easy start and regulation of the device's power, connected to the inlet of primary air passing through the casing of the container and casing of the integral lining. The nozzles of the primary air the support pyrolytic decomposition of the fuel, while the temperature inside the device slowly increases, which affects the function and performance of the device. Depending on the amount of air pushed into the device, the speed of pyrolytic decomposition of fuel, the temperature in the device, and the quantity of gaseous substances produced all change.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, the nozzles are radially arranged to line the inner circumference of the integral liner. If the air jets would not bring air around the entire perimeter of the integral liner, this would result in the formation of one pyrolysis focal point of fuel in the interspace of the integral liner, and the fuel would be distributed unevenly, and the non-distributed fuel would clog the reduction zone and have a negative impact on the operation of the equipment.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, the integral liner inside has at least one support that bears a refractory casing, wherein through the support there passes, through the casing of the container and through the casing of the integral lining, an inlet for secondary air which leads to nozzles of secondary air arranged below the refractory casing. In the partial oxidation chamber there must be, for the course of the oxidation, a sufficient amount of oxygen, which is fed into the chamber by the secondary air inlet. The tar is degraded into simpler compounds in the free space of the partial oxidation chamber.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, a feeder opens to the upper part of the container with airtight stoppers for the supply of fuel and opening up above the hopper, while a mixer is also arranged in the upper part of the container that extends into the hopper. The feeder is hermetically sealed in order to prevent the loss of pressure when filling the hopper of the device which would lead to a disruption of the pressure environment within the container of the device. The change in pressure would affect the process of pyrolytic decomposition of the fuel and would have an impact on the device's performance. The mixer ensures sufficient fuel distribution to each channel of the set of pyrolysis channels.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, in the bottom part of the container there is a movable grate for shoveling the ash for its removal to the discharge pipe, equipped with an airtight stopper. Even when shoveling the ash, the pressure balance in the device must be maintained to avoid affecting the performance of the device, while the grate evenly shovels the ash from around the entire the bottom of the device.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, there are supports distributed throughout the inner circumference of the integral lining, wherein between the supports there are gaps formed for the gravity fall of the pyrolysis residue of fuel from the surface of the refractory casing into the reduction zone. The supports must bear the weight of the refractory casing, which the fuel exerts pressure on, so there must be several of them and they must be strong enough, while at the same time it is necessary that the pyrolysis residue of the fuel can fall into the reduction zone, necessitating the gaps between the supports.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, there are vents in the refractory casing arranged vertically above one another and are obliquely oriented to prevent the ingress of pyrolysis residues of fuel into the vents. If fuel residues would penetrate into the vents, this would result in plugging or cause an accumulation of residues in the partial oxidation chamber, thereby decreasing its void volume and decreasing the efficiency of the decomposition of tars.

In another preferred embodiment of the device for multi-stage gasification of carbonaceous fuels according to the submitted invention, the integral lining is a steel weldment, the number of vertical pyrolysis channels is from one to eight, and a cross-section of the vertical pyrolysis channels forms a circle or circular arc. The more pyrolysis channels the integral lining includes, the larger the heat transfer area is, resulting in a more efficient heat transfer from the product gas to the fuel, while on the other hand, the smaller the amount of fuel inset in the integral lining is, and the hopper must be more actively filled.

The advantages of the device according to the invention consist in a low tar content in the product gas, in the ease of operation of the device's performance, in almost wasteless operation, in a wide range of dimensions of the overall performance of the device, in the use of the heat of the product gas, and in the possibility of using fuels of different granulometry.

Description of the drawings

The invention will be clarified more closely in the following drawings, in which Fig. 1 shows a vertical sectional view of the device, Fig. 2 shows a horizontal sectional view of the container and integral lining with one pyrolysis channel with a circular cross-section, Fig. 3 shows a horizontal sectional view of the container and integral lining with four pyrolysis channels with circular arc cross-sections, and Fig. 4 shows a horizontal sectional view of the container and integral lining with four pyrolysis channels with circular cross-sections.

Examples of the preferred embodiments of the invention

It should be understood that the hereinafter described and illustrated specific examples of the realization of the invention are presented for illustrative purposes and not as a limitation of the examples of the realization of the invention to the cases shown herein. Experts who are familiar with the state of technology shall find, or using routine experimentation will be able to determine, a greater or lesser number of equivalents to the specific realizations of the invention which are specifically described here. These equivalents shall also be included into the scope of the claims.

The device **1** for multi-stage gasification of carbonaceous fuels **2** according to Fig. 1 consists of a vertical cylindrical container **3**. The container **3** has a cylindrical shape and is made of refractory steel. The outer casing of the container **3** is lined with a thermal insulation plate **4** for high temperatures. The upper base of the container **3** is basically formed into a conical shape, while on its top a driver is mounted, in a vertical downward direction, for the mixer **16**. Through the upper base of the container **3** there is an airtight feeder **22** for fuel **2**. The carbonaceous fuel **2** consists of wood chips with a moisture content of 10% - 15% while the size of the fraction of fuel **2** is 5 mm to 50 mm.

The lower base of the container **3** forming the bottom is horizontal and is equipped (not shown in Fig. 1) with a water cooling system for the bottom for cooling the ash **5** as it is being removed. At the bottom of the container **3** there is placed a rotary grate **18** with rectangular arms for moving the ash **5** into the outlet pipe **19** with airtight valves for maintaining the pressure conditions inside the container **3**.

Inside the container **3**, a weldment from sheet steel is inserted, forming an integral lining **14**. The integral lining **14** passes through almost the entire height of the container **3**, wherein, between the outer side of the wall of the integral lining **14** and the inner side of the wall of the container **3**, a space is created for the product gas **11** to pass through. In the upper part of the container **3** near the top base, the integral lining **14** forms a hopper **23** for the fuel **2**, in which the mixer **16** moves and into which the feeder 22 for the fuel 2 opens up. The hopper 23 extends completely through the cross-section of the container 3.

In this particular realization of the invention, the hopper 23 of the integral lining 14 opens in a downward direction through the container 3 into a set of four pyrolysis channels 15 which are formed by pipes and between which there is a free space. In other instances of the realization, the number of pyrolysis channels 15 and their cross-sections may differ, for example, only three pyrolysis channels 15 with a cross-section in the shape of circular arcs.

The pyrolysis channels 15 open up into the central part of the integral lining 14, forming an interspace 6. Along the inner side of the wall of the integral lining 14 in the interspace 6, a fireclay lining 26 is formed, through which primary air nozzles 17 pass around the entire circumference. The primary air inlet 25 passes through the wall of the container 3 and the wall of the integral lining 14.

The integral lining 14 opens up above the bottom base of the container 3, wherein the fireclay lining 26 is walled along the inner circumference over where it opens; on the fireclay lining 26 there are placed, with sufficient spacing, supports 20 for supporting a conical ceramic casing 8 of the partial oxidizing chamber 7. Throughout these supports 20 and passing into the partial oxidation chamber 7 there are nozzles 24 supplying secondary air from the inlet 12. The ceramic casing 8 is equipped with vents 9 oriented obliquely upward so that the pyrolysis residue of the fuel 2 does not fall into the partial oxidation chamber 7. The product gas 11 is discharged from the container 3 through outlet 13 in the area above the hopper 23.

During operation of the device 1, the fuel 2 descends through the heated pyrolysis channels 15, dries, then its gradual pyrolysis occurs through the influence of the transmitted heat. The evaporated moisture from the fuel 2 in the form of steam and later the released volatile component sequentially flow through the entire cross-section of each pyrolysis channel 15, the fuel 2 heats up, so the fuel 2 is pyrolyzed at a greater distance from the heat exchange surface of the pyrolysis channel 15, so that upon the exit of fuel 2 from the pyrolysis channels 15 into the interspace 6 above the partial oxidation chamber **7**, the fuel **2** is spread over the carbon-containing pyrolysis remainder of the fuel **2** and the volatile component.

A horizontal cross-section of the pyrolysis channels **15**, which may have varying cross-sections, is shown in Fig. 2 to 4, where the optimum design of the shapes of cross-sections of pyrolysis channels **15** is indicated. The simplest shape of the pyrolysis channel **15** is formed by a pipe. An increase in the total pyrolysis heat exchange surface may be achieved, for example, by increasing the total number of pyrolysis channels **15**. A square shaft with an n-angle section may also serve as a pyrolysis channel **15**.

The pyrolysis residue of the fuel **2** falls freely along the outer contour of the conical casing **8** of the partial oxidizing chamber **7**, which is made of refractory ceramic or alloy, and gradually flows into the reduction zone **10** located below the partial oxidizing chamber **7**. The refractory casing **8** is supported by several (e.g. four) supports **20**, between which are wide gaps **21** allowing the pyrolysis residue of the fuel **2** to enter into the reduction zone **10**.

The gaseous component released from the fuel **2** above the partial oxidizing chamber **7** passes through the oblique vents **9** in the cone of the casing **8** into the partial oxidation chamber **7**. Into this chamber **7**, nozzles **24** connected to the secondary air inlet **12** enter tangentially in the bottom part. This is also the most frequent air. Partial combustion (oxidation) of the volatile components and of the gas released from the fuel **2** occurs, and the temperature in the partial oxidation chamber **7** increases to 1000-1200° C. This leads to the thermal decomposition of the tars in the volatile components and in the released gas. This is also greatly contributed to by the long time that the released gas remains in the partial oxidation chamber **7**, due to its large volume as delimited by the cone of the casing **8**.

After passing through the heated reduction zone **10**, the hot gases from the partial oxidation chamber **7** are stripped of residual tars, and their potential calorific value is also increased by reduction of the resulting CO^2 to CO, which is flammable. The resulting gas mixture, which creates product gas **11**, then freely exits through the space between the casing of the integral liner **14** and casing of the container **3** and further through the space between the pyrolysis channels **15** out of the device through outlet **13** for product gas **11**. Along the way, the product gas **11** transfers heat to the fresh inserted fuel **2** descending through the pyrolysis channels **15**. The reduction of temperature of the exiting product gas **11** and the use of its heat for the drying out and pyrolysis of the fuel **2** in the pyrolysis channels **15** substantially increases the thermal efficiency of the device **1**. It is also important to completely insulate the container **3** with insulation **4** around the outer casing of the container **3**.

When warming up the device **1** and also when changing the desired power, a system of nozzles **17** connected with the primary air inlet **25** is used, wherein this system is located around the circumference of the interspace **6** above the conical casing **8** of the partial oxidizing chamber **7**. By connecting a burner (not depicted) to the primary air inlet **25**, the fuel **2** ignites, thereby increasing the temperature in the partial oxidation chamber **7**. After increasing its temperature above 450°C it is possible to regulate the opening of the inlet **12** of secondary air flowing through the nozzles **24** into the partial oxidation chamber **7** where the temperature begins to rapidly increase. After its stabilization to a set temperature between 1000°C - 1200°C and a sufficient heating of the reduction zone **10**, the product gas **11** is ready for use in a cogeneration unit.

The supply of secondary air **12** is regulated so that even during the exchange-related stress to the device **1**, the desired temperature in the partial oxidation chamber **7** is maintained. The primary air introduced into the radially formed nozzles **17** around the periphery of the integral body **14** in the lining **26** is regulated so that the vacuum above the fuel **2** in the hopper **23** is maintained in a range from 50 to 100 mbar.

Regulation of the inlet **12** of secondary air and the presence of the nozzles **17** have a great importance for the power flexibility of the device **1** for the gasification of carbonaceous fuels **2**. The area of pyrolysis channels **15** may have different shapes, which, with sufficient dimensioning, allows for the use of fuel with 40% moisture content, thereby saving investment costs designated for the construction of a drying apparatus.

In another design (not depicted) of the device **1**, the casing **8** is fixed to the inner side of the wall of the integral lining **14**, and the space delimited by the casing **8** of the partial oxidizing chamber **7** has the shape of an inverted cone oriented with the outlet opening downwards, whereas the partial oxidation chamber **7** itself is located under the casing **8** and, delimited by the cone, the pyrolysis residue of fuel **2** descends towards the interconnecting top of the cone, through which it falls into the reduction zone **10** located below the partial oxidation chamber **7**. In the casing **8** there are vents **9** or slits for the passage of gas **11** with tar content into the partial oxidation zone **7**, into which nozzles **24** open, supplied with secondary air from the inlet **12**.

Industrial applicability

The device for multi-stage gasification of carbonaceous fuels according to the invention is useful for producing very pure generator gas with a minimal tar content (below 20 mg/m^3) for direct use in cogeneration units for the production of electricity and heat with high efficiency.

Overview of the positions used in the drawings

1	device
2	carbonaceous fuel
3	container
4	insulation
5	ash
6	interspace
7	partial oxidation chamber
8	refractory casing
9	vent
10	reduction zone
11	product gas
12	inlet for secondary air
13	outlet for product gas
14	integral liner
15	pyrolysis channel
16	mixer
17	primary air nozzle
18	grate
19	discharge pipe for ash discharge
20	support
21	gap
22	fuel feeder
23	hopper
24	secondary air nozzle
25	primary air inlet
26	lining

CLAIMS

1. A device (1) for multi-stage gasification of carbonaceous fuels (2) comprising a hermetically sealed vertical container (3) with a pyrolysis chamber; the container (3) is fitted with insulation (4) and is adapted for filling with carbonaceous fuel (2) from above the container (3) and for the removal of ash (5) from the bottom of the container (3), further comprising a partial oxidation chamber (7) for oxidation of the pyrolysis products delimited by a refractory casing (8) which is basically delimited in shape to cone-shaped, cylindrical, or pyramidal, and which is fitted with oblique ducts (9), and comprising a reduction zone (10) for the chemical reduction of oxidized product gas (11) released from the partial oxidation chamber (7), wherein into the container (3) there is led at least one inlet (12) of secondary air and out of the container (3) there is led at least one outlet (13) of product gas (11), **characterized in** that the reduction zone (10) is arranged under the casing (8) of the partial oxidation chamber (7) inside the container (3), forming a retarder for slowing the progression of carbonized pyrolysis residue of fuel (2) through the container (3) vertically oriented towards the reduction zone (10), and further that the outlet (13) of the product gas (11) is arranged beyond the reduction zone (10) in the direction of the progression of the product gas (11) out of the device (1).

2. The device according to claim 1, **characterized in** that the pyrolysis chamber forms at least one vertically oriented pyrolysis channel (15) for passage of the fuel (2) into the partial oxidation chamber (7), separated from the container (3), and that between the pyrolysis channel (15) and the container (3) there is a space for the passage of the product gas (11) from the bottom part of the container (3) into the upper part of the container (3) by bypassing the pyrolysis channel (15) to an outlet (13) for the product gas (11) arranged in the upper part of the container (3).

3. The device according to claim 1 and 2, **characterized in** that inside the container (3) there is arranged an integral lining (14) which forms, in the top area of the container (3), a hopper (23) opening into a system of vertical pyrolysis channels

(15), which are arranged separately from each other and from the container (3), and jointly open into the middle part of an integral lining (14) that forms an interspace (6) and a partial oxidizing chamber (7) with a refractory casing (8), and the bottom part of the integral liner (14) forms a reduction zone (10), wherein between the outer casing of the integral liner (14) and the inner wall of the container (3) there is a space for passage of the product gas (11) from the reduction zone (10) by bypassing the integral lining (14) into an outlet (13).

4. The device according to claim 3, **characterized in** that the integral lining (14) contains nozzles (17) for primary air for easy starting and regulating the power of the device (1), connected to the primary air inlet (25) passing through the casing of the container (3) and casing of the integral liner (14).

5. The device according to claim 4, **characterized in** that the nozzles (17) are radially arranged in the lining (26) on the inner circumference of the integral lining (14).

6. The device according to claim 3, **characterized in** that the integral lining (14) has at least one support (20) inside bearing a refractory casing (8), wherein through the support (20) there passes, through the casing of the container (3) and through the casing of the integral liner (14), a secondary air inlet (12) opening into a nozzle (24) of secondary air arranged below the refractory casing (8).

7. The device according to claim 3, **characterized in** that into the upper part of the container (3) a feeder (22) opens, with an airtight stopper for the supply of fuel (2), which opens into a hopper (23), while in the upper part of the container (3) there is also arranged a mixer (16) that extends into the hopper (23).

8. The device according to at least of one of claims 1 to 7, **characterized in** that in the bottom part of the container (3) there is a movable grate (18) for shoveling ash (5) into a discharge pipe (19) for the removal of ash (5) and which is equipped with airtight stoppers.

9. The device according to claim 6, **characterized in** that the supports (20) are arranged along the inner circumference of the integral lining (14), wherein between the supports (20) there are gaps (21) created for the gravity fall of the pyrolysis residue of the fuel (2) from the surface of the refractory casing (8) into the reduction zone (10).

10. The device according to at least one of claims 1 to 9, **characterized in** that the vents (9) in the refractory casing (8) are arranged vertically one above the other and are obliquely oriented to prevent the ingress of pyrolysis residues of fuel (2) into the vents (9).

11. The device according to at least one of claims 3 to 10, **characterized in** that the integral lining (14) is a steel weldment, that the number of vertical pyrolysis channels (15) is from one to eight, and that a vertical cross-section of the pyrolysis channels (15) forms a circle or circular arc.

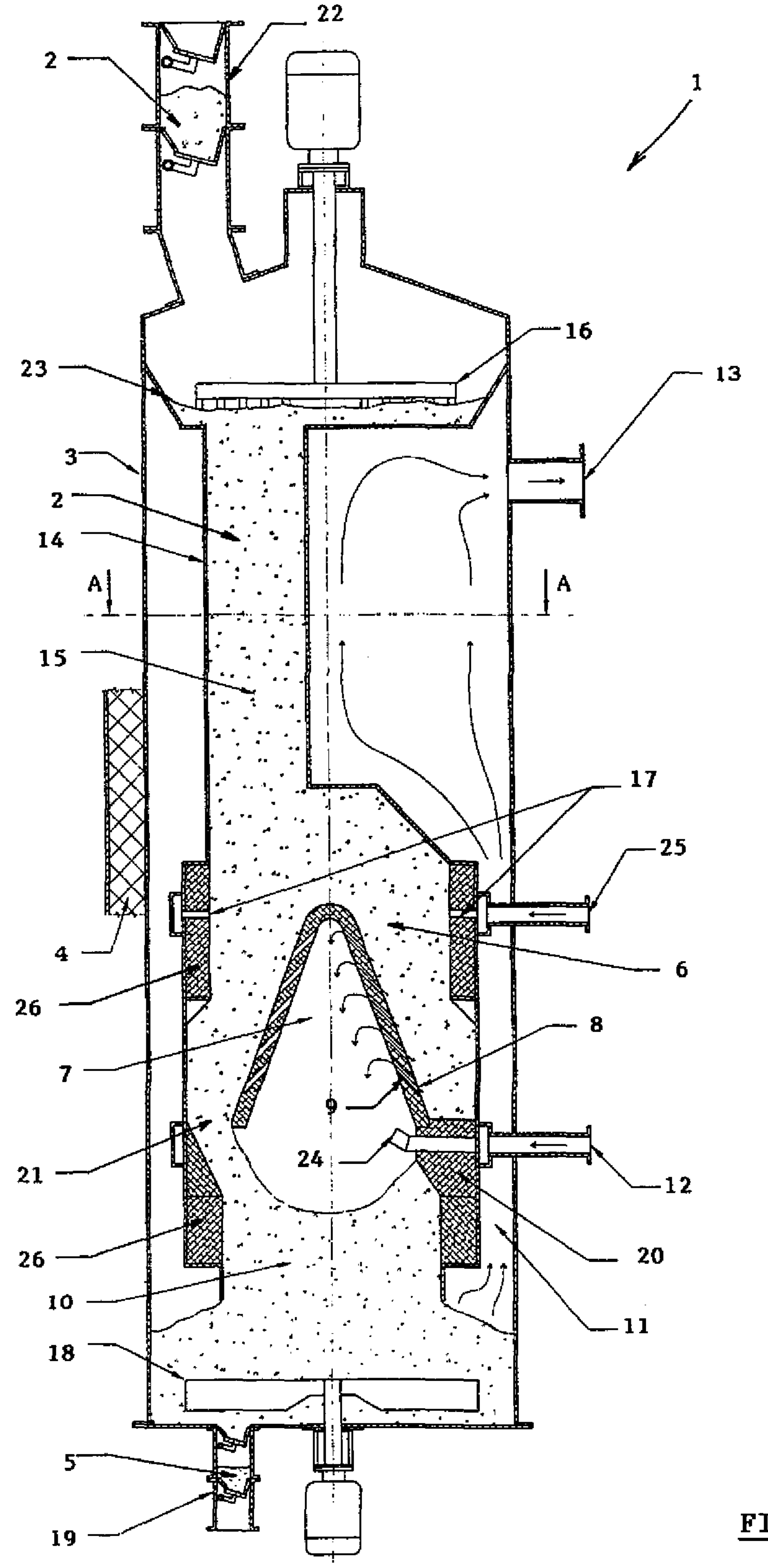

FIG.1

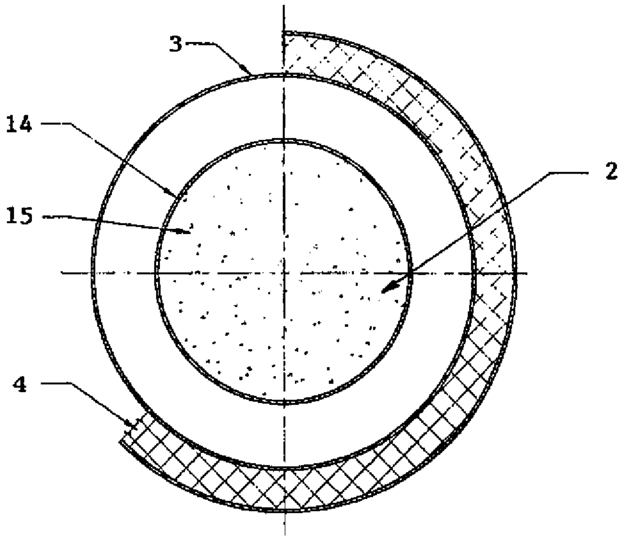

FIG.2

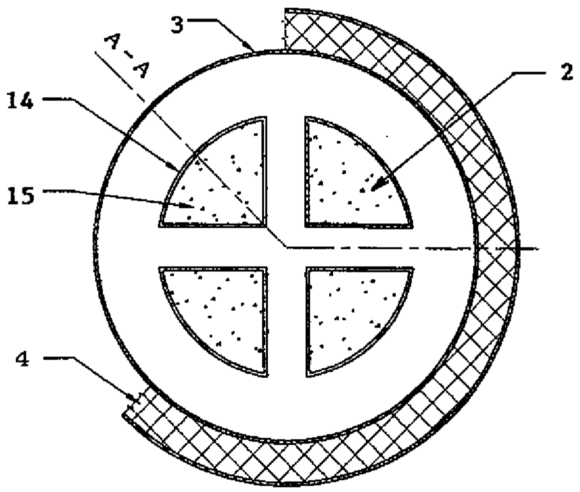

FIG.3

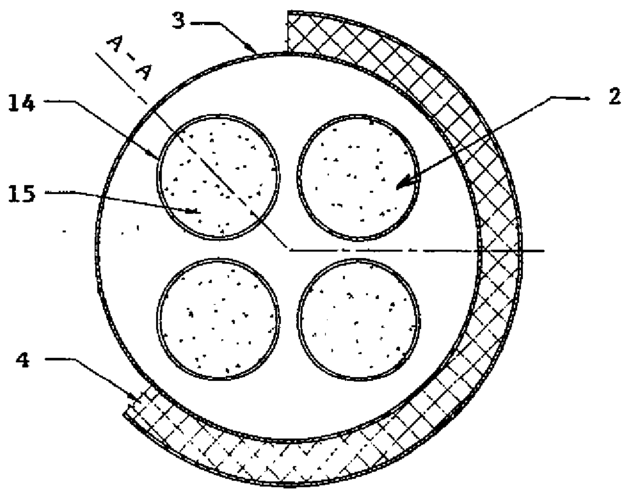

FIG.4

INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2013/000173

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10J3/32 C10J3/40 C10J3/66 C10J3/74 C10K3/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10J C10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 226 927 A (RUNDSTROM DAVID A [US]) 13 July 1993 (1993-07-13) column 4, line 20 - column 9, line 55; figure 1	1-9,11 10
Y	EP 0 532 901 A1 (TOMADINI GINO & C [IT]) 24 March 1993 (1993-03-24) page 10, line 33 - page 10, line 37; figures 1, 3	10
A	DE 10 2010 033646 A1 (PYROX GMBH [DE]) 11 August 2011 (2011-08-11) the whole document	1-11
A	DE 20 2006 009174 U1 (RUDOLF HOERMANN GMBH & CO KG [DE]) 11 October 2007 (2007-10-11) the whole document	1-11
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 April 2014	25/04/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Iyer-Baldew, A

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/097928 A1 (SCHWARZ ARMIN [DE] ET AL) 25 April 2013 (2013-04-25) the whole document -----	1-11
A	WO 2009/093107 A1 (ARSLAN HACI MEHMET [TR]) 30 July 2009 (2009-07-30) the whole document -----	1-11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/CZ2013/000173

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5226927 A	13-07-1993	NONE	
EP 0532901 A1	24-03-1993	AT 128175 T	15-10-1995
		DE 69204948 D1	26-10-1995
		DE 69204948 T2	25-04-1996
		DK 0532901 T3	13-11-1995
		EP 0532901 A1	24-03-1993
		ES 2079115 T3	01-01-1996
		IT 1252838 B	28-06-1995
DE 102010033646 A1	11-08-2011	DE 102010033646 A1	11-08-2011
		EP 2531576 A2	12-12-2012
		WO 2011095347 A2	11-08-2011
DE 202006009174 U1	11-10-2007	DE 202006009174 U1	11-10-2007
		DK 1865046 T3	15-10-2012
		EP 1865046 A1	12-12-2007
		EP 2377911 A2	19-10-2011
		ES 2393408 T3	21-12-2012
		SI 1865046 T1	31-01-2013
US 2013097928 A1	25-04-2013	CN 102844409 A	26-12-2012
		EP 2536811 A1	26-12-2012
		JP 2013519761 A	30-05-2013
		RU 2012139452 A	27-03-2014
		US 2013097928 A1	25-04-2013
		WO 2011101022 A1	25-08-2011
WO 2009093107 A1	30-07-2009	TR 200800384 A2	21-08-2009
		WO 2009093107 A1	30-07-2009