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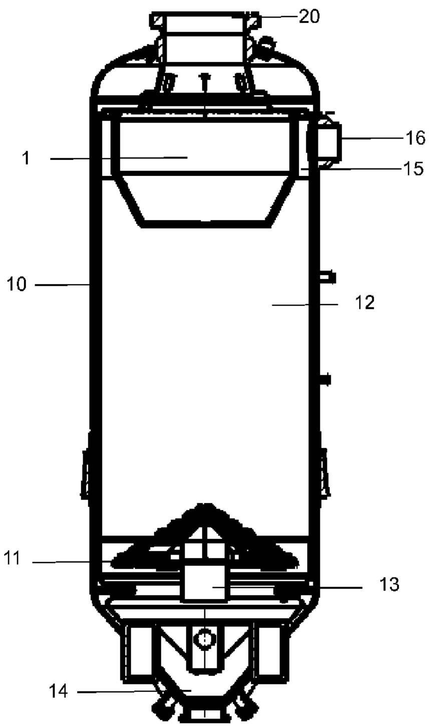

Fig. 1

(57) **Abstract**: In the gasification of carbonaceous solids with oxygen and/or steam in a fixed bed, the reactor (10) operated under pressure must continuously be charged with the solids. These solids are supplied to the fixed bed (12) from a lock via a ring-shaped apron (1) open at the top and at the bottom. This apron (1) includes an inner and an outer jacket, so that a cooling gap is formed with at least one inlet and/or outlet for a cooling medium.

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Cooled Annular Gas Collector

This invention relates to an apparatus for charging a reactor operated under pressure with carbonaceous solids, in which the solids are gasified with oxygen and/or steam in a fixed bed, wherein the apparatus includes a ring-shaped apron open at the top and at the bottom, to which the solids are supplied through a lock, and furthermore to a reactor for the fixed-bed gasification with this apparatus and to a method for operating such a reactor.

Gasification is understood to be the conversion of a carbonaceous solid or liquid substance (e.g. coal, biomass or petroleum) with a gasification medium (oxygen/air, steam) into so-called synthesis gas. As main components, this synthesis gas contains hydrogen (H_2), water (H_2O), carbon monoxide (CO), carbon dioxide (CO_2), and methane (CH_4). CO and H_2 are the starting substances for a plurality of chemical syntheses, based on which longer-chain products, such as gasoline and diesel as so-called CtL fuels (Coal to Liquids), or other valuable materials (SNG = Substitute Natural Gas, H_2 for ammonia/fertilizers/urea, methanol etc.) can then be produced.

The synthesis gas, however, also contains hydrogen sulfide (H_2S), carbon oxide sulfide (COS), hydrochloric acid (HCl), ammonia (NH_3), hydrocyanic acid (HCN), partly hydrogen fluoride (HF) and possibly also higher hydrocarbons and tar oils. The composition of the gas is dependent on the composition of the feedstock, the kind and quantity of the gasification media used, the reaction conditions and the kinetic boundary conditions of the occurring reactions as specified by the chosen gasification process.

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In principle, three different types of processes for the gasification of solids are known: The gasification in fluidized beds, the gasification in a fixed bed formed of the solids, and finally the gasification in an entrained-bed reactor. The different gasification technologies impose different requirements on the fuel, which must be taken into account correspondingly in the choice of the fuel or the conception of the fuel processing.

When the actual reactor is designed as fixed-bed reactor, it includes a substantially cylindrical vertical reactor with outer water jacket. The solid carbonaceous fuel, in general coal or biomass, is introduced from above through a lock into the coal distributor present in the interior of the reactor, wherein a fixed bed is formed, which rests on a rotary grate arranged in the lower region of the reactor. From this lower region, oxygen and steam are blown into the fixed bed.

These hot gases flow through the fixed bed from the bottom to the top, whereas the solids are refilled from above through the lock system. Therefore, reference is also made to a counterflow fixed-bed gasification. Since the refilled solids have a temperature of about 40 °C, the entire fixed bed has a temperature profile in which the hottest part is located in the vicinity of the rotary grate and the temperature decreases upwards towards the solids supply. Corresponding to this temperature profile, different reactions take place inside the fixed bed. Therefore, reference often is also made to reaction zones, where there is no clear separation into individual regions, but the individual zones merge into each other. In the upper part of the gasifier in the vicinity of the refilled solids, drying and desorption of physisorbed gases are effected. Below the drying zone the so-called reaction zone is located, in whose upper part degassing of the solids is effected. Degassing is followed by the actual gasification of the solids according to the Boudouard reaction as well as the water gas and water-gas shift reactions. In the succeeding zone, the combustion of the solids is effected.

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The ash obtained in particular during the combustion falls through the rotary grate and is further discharged from there. The non-converted gas fractions of the reactants, mainly steam, nitrogen and argon, are withdrawn together with the formed synthesis gas via a gas draw provided above the fixed bed.

The lock system for supplying the fuel into the reactor is necessary, since the reactor is operated at a pressure of up to 100 barg, preferably up to 60 barg, particularly preferably at an operating pressure of at least 50 barg, and hence the solids must be introduced under pressure. Introducing via a lock system is effected discontinuously, wherein the fuel first is introduced under atmospheric conditions into the lock terminated by the reactor, then is pressurized in the lock system and is filled into the reactor under this pressure. Subsequently, the reactor is again closed against the lock system. To be able to nevertheless operate the process in the steady state under constant conditions, a further solids reservoir must therefore be provided inside the reactor, which ensures that the fixed bed always has the same height. For this purpose, various internals for example from Lurgi® or VEB PKM Anlagenbau Leipzig, such as so-called coal distributors, are known. Attempts have been made to selectively influence the natural segregation of the coal grain spectrum by various designs of these apparatuses. The results only were suitable to a limited extent to achieve an improved gasification. Grain spectrum and disintegration behavior are very dependent on the type and properties of the coals.

Such apparatus is described for example in DE 11 2005 002 983 T5. This is a cylindrical or inwardly tapering, i.e. hollow inversely frustoconical apron with open end, which hangs down from the head of the reactor, so that coal which is drained from the coal lock moves along the inside of the apron, so as to be distributed in the solids bed. The lower end of the apron typically is located inside the fixed bed. Between apron and wall of the gas generator a ring-shaped

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gas collecting zone is formed, from which the raw gas collected there is withdrawn laterally through a gas outlet.

In the largest plants currently operated, coals mostly are converted to synthesis gas in a fixed-bed gasification process, in which the outlet and reaction end temperatures are so low on average that the synthesis gas obtained is withdrawn from the reactor with temperatures between 200 and 300 °C (for moist lignites) or between 400 and 450 °C (for young hard coals). A distinction must be made here between average temperature and temperature peaks caused by inhomogeneities of the fixed bed. The average temperature is decisive for the corrosion and thus the service life of the component. The temperature peaks determine the thermal and mechanical load and therefore must not exceed limit values.

The limit values of a plant for coal gasification in the fixed bed so far had to be defined such that at temperature peaks of 650 or 670 °C power reductions or even a shut-down of the reactor have become necessary, in order to limit the thermal load of the raw gas outlet. Poor coal qualities or properties and high loads increase the amplitude and frequency of such temperature peaks.

Due to the increasing shortage of fossil raw materials, solids gasifiers have to be designed such in the future that not only for example moist lignite or younger hard coals, but also other coals with higher reaction end temperatures and inferior properties can be gasified. In addition, the fixed-bed gasification of renewable raw materials or secondary raw materials is gaining in importance, which mostly have inferior properties with respect to the fixed-bed gasification. The temperatures resulting there canlead to gas outlet temperatures of at least 700 °C, preferably up to 800 °C, in part even up to 1000 °C. At these temperatures, the apron used is exposed to a distinctly greater material stress.

In addition, coals which have high contents of sulfur or halogens are gasified to an increasing extent. As mentioned already, this leads to compounds such as H_2S, COS, HCl and HF in the resulting raw synthesis gas. Together with temperatures which lie above the temperatures typically used so far (e.g. moist lignite about 250 °C, young hard coal about 450 °C, compared with older hard coal 450 - 550°C, anthracite 550 - 600°C), this leads to stronger corrosion at the apron. To these typical operating temperatures the temperature peaks also must be added, which depend on the quality and the grain spectrum of the coals. Greatly disintegrating lignites, for example, cause channeling due to the high content of fine grain, which leads to CO_2 and temperature peaks. For changing the apron, the plant must be shut down, so that production losses will occur. On the other hand, the apron is so large that the use of high-temperature resistant materials would cause a considerable increase in investment costs and therefore is uneconomic, all the more so as the use of high-temperature resistant materials would prevent corrosion e.g. by hydrogen halides only to a limited extent.

Therefore, it can be desirable for at least an embodiment of the present invention to design the apron also referred to as annular gas collector such that even at gasification temperatures above 450 °C and/or when using fuels containing sulfur and/or halogens, long service lives of the plant become possible. At the same time, frequent temperature peaks may have to be tolerated without enforcing a load reduction or a brief or longer-term shut-down of the reactor.

The invention provides an apparatus for charging a reactor operated under pressure with carbonaceous solids, in which the solids are gasified with oxygen and/or steam in a fixed bed, wherein the apparatus includes a ring-shaped apron open at a top and at a bottom, to which solids are configured to be supplied through a lock. The apron includes an inner jacket and an outer jacket, between which a cooling gap is formed with at least one inlet and/or outlet for the supply and discharge of a cooling medium. Between the inner jacket and the outer jacket of the apron a bulkhead is provided, so that an inner and an outer cooling gap are formed. The inner and the outer cooling gap are connected with each other at least at one point.

In accordance with a development of the invention, the apron is formed rotationally symmetrical, in particular cylindrical, conical or partly conical. A cylindrical shape may have the advantage that the fuel introduced through the lock system is spread over the entire cross-section of the fuel bed. In addition, the volume of the coal feeder chute thus can be maximized, so that with equal filling volume the same may have a comparatively short length and the effective reactor height may not be reduced decisively. Nevertheless, it may be possible to take up that amount of coal which is required to bridge the time between two coal locking operations and possible irregularities of gasification and feeding.

When the apron jacket is conical, in some embodiments the charging device can taper towards the fixed bed. This may have the advantage that the free exit surface for the raw gas from the fixed bed is as large as possible. By providing an exit surface as large as possible, the respective gas velocity and hence the entrained amount of dust can be minimized. In addition, the resulting gas collecting space may have a volume as large as possible, so that the flow velocity of the raw gas may also be decreased in the gas collecting space and the dust retention may be improved. Finally, the exit surface may be designed as large as possible, so that the raw gas can flow over the entire cross-section of the fuel bed more uniformly and the entrainment of coal particles may be minimized. In some embodiments, cross flows can be reduced, in order to ensure homogeneous reaction conditions in the entire fixed bed.

A partly conical formation, which is mounted on a cylindrical part, may combine the advantages of both designs.

In ongoing operation, the cooling gap may be charged with coolant, preferably boiler feed water. If water is used, in some embodiments the water must satisfy the guidelines for steam generators, in order to prevent deposits of carbonate or boiler scale. In principle, the cooling gap must be designed such that the inflow of the coolant is provided at one edge and the outflow of the coolant at the opposite edge. Preferably, however, the cooling gap may be designed liquid-impermeable at one edge, in that inner and outer jacket here are connected in a liquid-tight manner. Preferably, this edge may face the fixed bed, i.e. it may be arranged at the bottom in the reactor. Charging the cooling gap with coolant can be effected via a common supply and discharge conduit, or at least one inlet and one outlet may be provided.

At the edge of the apron facing away from the fixed bed, i.e. at the upper edge, the cooling gap may be closed by a preferably ring-shaped cover in which numerous openings may be provided for introducing and discharging the cooling medium. Cooling medium then can be introduced into the cooling gap over the entire circumference of the apron. When the cooling medium, e.g. water, is heated by the hot synthesis gas ascending past the outside of the apron, it may be evaporated and may rise to the top, in order to escape in vaporous form from the cooling gap through the openings of the cover.

Preferably, inner and outer jacket may extend in parallel, since the apparatus thus can be fabricated easily and the resulting cooling gap may have the same width at each point. In the same way, it may also be conceivable here to form the cooling gap such that at those points at which the volume flow of the gas along the apron and thus the heat quantity to be dissipated is particularly high it may have a greater width than at points traversed little. For example, the region facing the gas outlet may be subjected to a great load. Hence, it can be ensured that actually the entire apron is cooled sufficiently.

A bulkhead is provided between inner and outer jacket of the apron, which preferably may extend parallel to the inner and outer jacket, in order to provide for uniform charging with cooling liquid. By the bulkhead, an inner and an outer cooling gap are formed, which are connected with each other at least at one point, preferably over the entire circumference of the apron.

The connection between the inner and the outer cooling gap may be accomplished particularly easily in that between the bulkhead and a jacket portion connecting the inner jacket with the outer jacket a free space may be provided, i.e. the bulkhead may not extend down to the bottom of the apron. With this design it may be achieved that the coolant flows through the apron without a pump being required: The outer cooling gap may adjoin the outer jacket of the apron, which may be in direct contact with the gas collecting space and may be exposed to the temperature of the ascending hot raw synthesis gas, so that it is heated up correspondingly. Via the inner jacket, the coolant in the inner cooling gap may be connected with the refilled solids which may only have a temperature of about 40 °C. The coolant in the outer cooling gap may therefore be exposed to a distinctly higher heat transfer than the coolant in the inner cooling gap, so that a directional flow through the cooling gap can occur due to convection.

When water now is used as cooling liquid, the boiling point of the water may be below the temperature of the hot raw synthesis gas. This may also be the case when the cooling system is operated under pressure (30 bara: boiling point 234 °C; 51 bara: 265 °C). The resulting steam may always flow upwards to the outlet. In a particularly preferred aspect, the coolant may be supplied to the inner cooling gap and withdrawn from the outer cooling gap. Thus, the introduced cooling water may pass through the inner cooling gap, may be slightly heated up by contact with the bulkhead, and may pass this heat on to the refilled solids in the interior of the apron, which to a minor extent can even lead to a decrease in the cooling water temperature, and may then get into the outer cooling gap. As a result of the contact with the hot outer jacket of the apron, the water may be evaporated there and may thus withdraw heat from the system. The resulting steam may flow out of the steam outlet provided in the outer cooling gap. Due to the escape of the steam, new cooling water may continuously be conveyed from the inner cooling gap into the outer cooling gap. In this system, inner and outer cooling gap may thus be traversed by natural convection. The natural convection may be defined by the density difference of the water column in the inlet and the steam-water column in the outlet. This may result in a so-called circulation number as quotient of steam generation and water circulation, which may be limited by the pressure loss with a given geometry. The apparatus may operate particularly effectively when inflow and outflow of the cooling water are effected at the upper edge of the apron with a vertical construction of the reactor.

Preferably, the bulkhead may be designed such that the inner cooling gap has a smaller width than the outer cooling gap. This may have the advantage that when using water as coolant, the resulting steam may provide sufficient volume in the outer cooling gap. Thus, an optimum circulation number of water/steam can be made possible and the pressure loss can be minimized.

Another aspect of the invention provides a reactor for gasifying carbonaceous solids with oxygen and steam in a fixed bed, comprising an apparatus as set forth above. Such reactor may include a rotary grate in the vicinity of the bottom and a solids lock at the head of the reactor, which may be followed by the apron described above.

Advantageously, the reactor may be formed such that the inlet and/or the outlet of the cooling gap of the apron is/are connected with a cooling system of the reactor itself. This may have the advantage that for cooling the apron no separate cooling circuit need be installed and investment costs thus can be lowered, and in addition the reliability and operational safety of the cooling system can be increased. Preferably, the reactor may itself likewise have a cooling jacket into which the cooling jacket of the apron is integrated.

Furthermore, apron and reactor may preferably be welded to each other. This may become possible in that by cooling the apparatus the temperature of inner and outer jacket can be lowered distinctly as compared to an uncooled apron. When water below 51 bara is used as cooling liquid, the boiling temperature is about 265 °C and thus lies distinctly below the critical temperature of 300 °C, from which hot gas corrosions progressively occur for carbon steel. In that due to cooling the apron may be protected against corrosion, but also against erosion as a result of the coal moving downwards, it no longer must be replaced regularly, so that expensive, releasable connections may not be necessary.

Another aspect of the invention relates to a process for gasifying carbonaceous solids with oxygen and steam. The gasification is carried out in a fixed bed operated under pressure and the solids are introduced via a lock through an apparatus as set forth above into the fixed bed. A cooling medium is introduced into the jacket in liquid form into a cooling gap of the apparatus and withdrawn at least partly in vaporous form. By such cooling, the apparatus can effectively be protected against corrosion and at the same time a slight first cooling of the hot raw synthesis gas can be effected, so that the succeeding components also are loaded less.

Such cooling may be particularly advantageous when the steam withdrawn can be reused energetically inside the process as reactant/gasification medium. Inside the fixed-bed gasification, the steam acts as "moderator", in order to limit the combustion temperature such that the coal ash is not molten. In some embodiments, the steam must be added in the excess.

The use of the steam may turn out to be quite particularly advantageous in some embodiments when water is used as cooling liquid and the cooling water withdrawn in vaporous form itself can be used as reactant, i.e. that steam stream which is required for gasifying the solids in the fixed bed can partly be fed with the steam generated in the cooling. The steam requirement of the process thereby can be lowered, which may lower the operating costs. When the reactor itself also includes a water-cooled jacket and steam is formed here as well, about 20 vol-% of the required total steam quantity can be saved by the collected recirculation of the steam from all cooled components.

Further features, advantages and possible applications of embodiments of the invention can also be taken from the following description of an exemplary embodiment and the non-limiting drawings. All features described or illustrated form the subject-matter of embodiments of the invention per se or in any combination.

In the drawings:

Fig. 1 schematically shows a fixed-bed reactor operated in counterflow,

Fig. 2 shows an annular gas collector according to an embodiment of the invention,

Fig. 3 shows a cover of the annular gas collector according to an embodiment of the invention.

Fig. 1 schematically shows the reactor 10. It is a vertical fixed-bed reactor operated in counterflow, which includes a rotary grate 11 in the vicinity of the bottom.

On this rotary grate 11 a solids bed 12 is built up in operation. Via a feeder 13, steam and/or an oxygen-containing medium, such as air, oxygen-enriched air or also pure oxygen is introduced and injected into the bed 12 from below evenly distributed. Ash which is formed by reactions in the fixed bed 12 is discharged through the rotary grate 11 and removed via an ash draw 14 with succeeding ash lock. The reactor 10 is water-cooled and includes a cooling gap 17 between an outer jacket 18 and an inner jacket 19 (Figure 2).

Above the reactor 10 a lock 20 is provided, via which coal or other carbonaceous solids are supplied. The lock 20 is followed by an apron 30 displayed in Figure 2, which serves as solids reservoir, so that the fixed bed 12 in the reactor 10 has a uniform and sufficient filling level, although charging with coal is effected discontinuously through the lock 20. Above the fixed bed 12 a free space is provided around the apron 30, in which reaction gases as well as unused steam are collected. The gases collected in this gas collecting space 15 are withdrawn via a gas draw 16.

Fig. 2 shows the right half of the charging device 1 according to an embodiment of the invention schematically and in section. The gas draw 16 mostly is provided on one side of the reactor only.

The charging device 1 includes a double-walled apron 30 with an inner jacket 31 and an outer jacket 32, between which a cooling gap 33 is formed. At the lower end of the apron 30 facing the fixed bed 12, the inner jacket 31 and the outer jacket 32 are connected in a liquid-tight manner by a jacket portion 35. Inside the apron 30, a bulkhead 34 is provided between the inner jacket 31 and the outer jacket 32. This bulkhead 34 divides the cooling gap 33 formed between inner jacket 31 and outer jacket 32 into an inner cooling gap 33i and an outer cooling gap 33a. In ongoing operation, the inner cooling gap 33i adjoins the solids retained in the apron 30 via the inner jacket 31, while the outer cooling gap 33a adjoins the gas collecting space 15 and the fixed bed 12 via the outer jacket 32.

Between the bulkhead 34 and the jacket portion 35 connecting the inner jacket 31 and the outer jacket 32 a free space 36 is provided, by which the inner cooling gap 33i and the outer cooling gap 33a are connected with each other at the lower end of the apron 30.

The cooling liquid, preferably water, is introduced between bulkhead 34 and inner jacket 31, flows downwards by gravity and is in heat exchange with the cold coal (about 40 °C) provided inside the apron. Since the bulkhead 34 does not terminate flush with the jacket portion 35, the water can enter into the outer cooling gap 33a at the lower edge of the apron 30. In the outer jacket 32, the cooling liquid is in direct heat exchange with the hot gas in the gas collecting space 15. Due to the temperature of the gas of up to 700 °C, preferably up to 800 °C, the water is heated to temperatures of the respective boiling point (at an operating pressure of 51 bara about 265 °C) and evaporated. Due to its distinctly lower density, the steam rises upwards (convection) in the outer cooling gap 33a and can be withdrawn at the upper end of the cooling gap 33a. The surface temperature of the outer jacket 32 will be higher than the cooling water temperature by up to 30° (depending on gas temperature and load), since the heat transfer is high on the gas side. At the outer jacket 32, there will still be obtained a temperature slightly below 300 °C, which lies distinctly below the temperature obtained in an uncooled annular gas collector, which substantially corresponds to the gas temperature. A hot gas corrosion of carbon steel can be avoided or at least greatly reduced.

When the reactor 10 itself likewise comprises a water-cooled jacket, the cooling gap 33 of the apron 30 preferably is connected with the cooling system of the reactor 10 such that the cooling water from the cooling gap 17 between outer

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jacket 18 and inner jacket 19 of the reactor 10 can also be utilized for charging the cooling gap 33 of the apron 30.

Fig. 3 shows a ring-shaped cover 40 which is mounted on the charging device 1, preferably welded to the same, and at the same time represents the inflow and outflow of the coolant as well as the connection to the reactor 10.

In the center of the cover 40 a circular opening 41 is provided, through which the solids can get from the lock system 20 into the charging device 1. Offset to the outside and associated to the jacket of the apron 30, two rows of openings 42, 43 are provided on concentric circles, via which the coolant is introduced into the inner cooling gap 33i and withdrawn from the outer cooling gap 33a, respectively. Via a circumferential projection 44, the cover 40 can be connected, e.g. welded to the inner jacket 19 of the reactor 10 (cf. Fig. 2).

In the cooled annular gas collector according to an embodiment of the invention, the abrasion at the inner jacket due to the coal constantly passing by is greatly reduced by the lower wall temperature, and the possible service life thereby is prolonged. Due to the lower temperature, hot gas corrosions at the outer jacket are avoided or greatly reduced independent of the concentration of the corrosive components in the raw gas. The corrosive components in the raw gas are determined by the coal composition.

In addition, the gas is slightly cooled at the outer jacket of the annular gas collector, which results in a lower temperature load of the succeeding plant sections. By cooling the gas at the annular gas collector, heat is withdrawn from the process at one point and the coolant is evaporated.

When water is used as coolant, the steam formed subsequently can be fed into the system as steam for the gasification, whereby the costs for the reactants to be provided can be lowered.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

List of Reference Numerals:

1	charging device
10	reactor
11	rotary grate
12	fixed bed
13	feeding of oxygen-containing gas and/or steam
14	ash draw
15	gas collecting space
16	gas draw
17	cooling gap
18	outer jacket of the reactor
19	inner jacket of the reactor
20	lock
30	apron
31	inner jacket
32	outer jacket
33	cooling gap
33a	outer cooling gap
33i	inner cooling gap
34	bulkhead
35	jacket portion
36	free space
40	cover
41	opening
42	openings
43	openings
44	projection

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Claims:

1. An apparatus for charging a reactor operated under pressure with carbonaceous solids, in which the solids are gasified with oxygen and/or steam in a fixed bed, wherein the apparatus includes a ring-shaped apron open at a top and at a bottom, to which solids are able to be supplied through a lock, wherein the apron includes an inner jacket and an outer jacket between which a cooling gap is formed with at least one inlet and/or outlet for the supply and discharge of a cooling medium,

wherein between the inner jacket and the outer jacket of the apron a bulkhead is provided, so that an inner and an outer cooling gap are formed, wherein the inner and the outer cooling gap are connected with each other at least at one point.

2. The apparatus according to claim 1, wherein the apron is formed rotationally symmetrical, in particular cylindrical, conical or partly conical.

3. The apparatus according to claim 1 or 2, wherein the inner jacket and the outer jacket of the apron are connected with each other on the lower side facing the fixed bed in the reactor.

4. The apparatus according to any one of the preceding claims, wherein at the upper edge of the apron facing the fixed bed the cooling gap is closed by a cover which includes a plurality of openings for supplying and discharging the cooling medium.

5. The apparatus according to any one of the preceding claims, wherein the inner and the outer cooling gap are connected with each other over the entire circumference of the apron.

6. The apparatus according to any one of the preceding claims, wherein between the bulkhead and a jacket portion connecting the inner jacket with the outer jacket a free space is provided.

7. A reactor for gasifying carbonaceous solids with oxygen and/or steam in a fixed bed, comprising an apparatus according to any one of the preceding claims.

8. The reactor according to claim 7, wherein the inlet and/or outlet of the cooling gap of the charging device is/are connected with a cooling gap between an inner jacket and an outer jacket of the reactor.

9. A process for gasifying carbonaceous solids with oxygen and steam, wherein the gasification is carried out in a fixed-bed reactor operated under pressure and the solids are introduced via a lock through an apparatus according to any one of claims 1 to 6 into the fixed bed, wherein a cooling medium is introduced in liquid form into a cooling gap of the apparatus and wherein the cooling medium is withdrawn from the cooling gap at least partly in vaporous form.

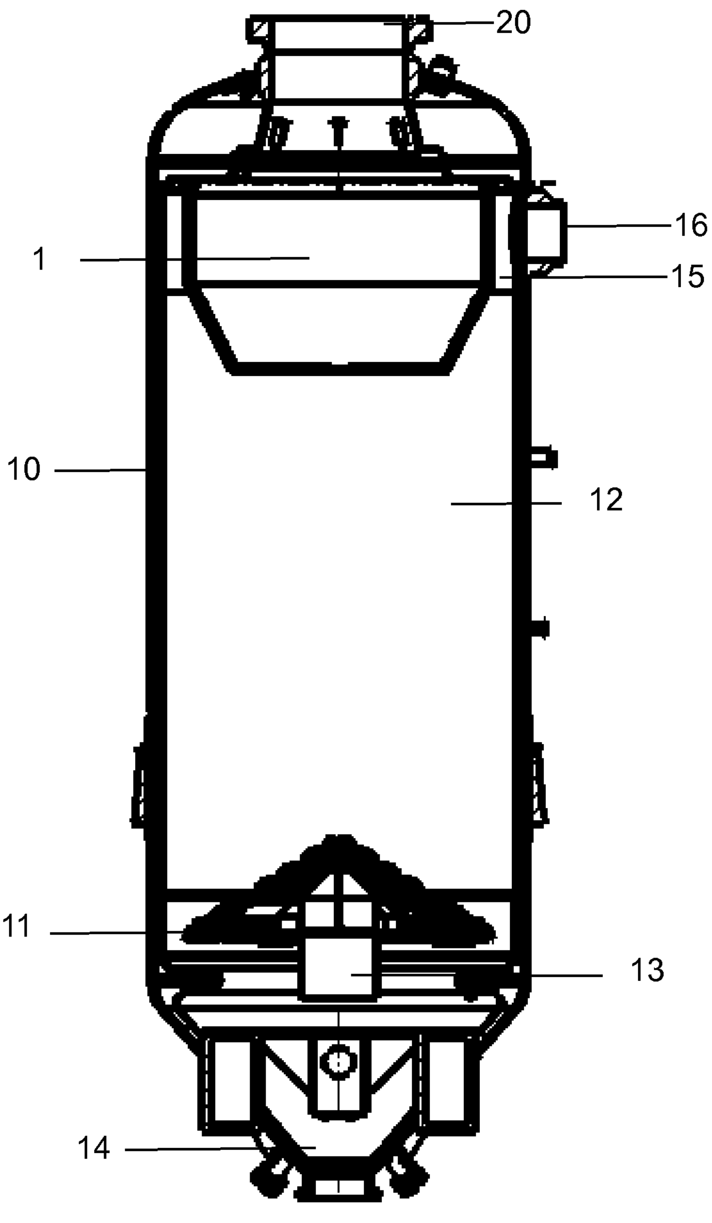

Fig. 1

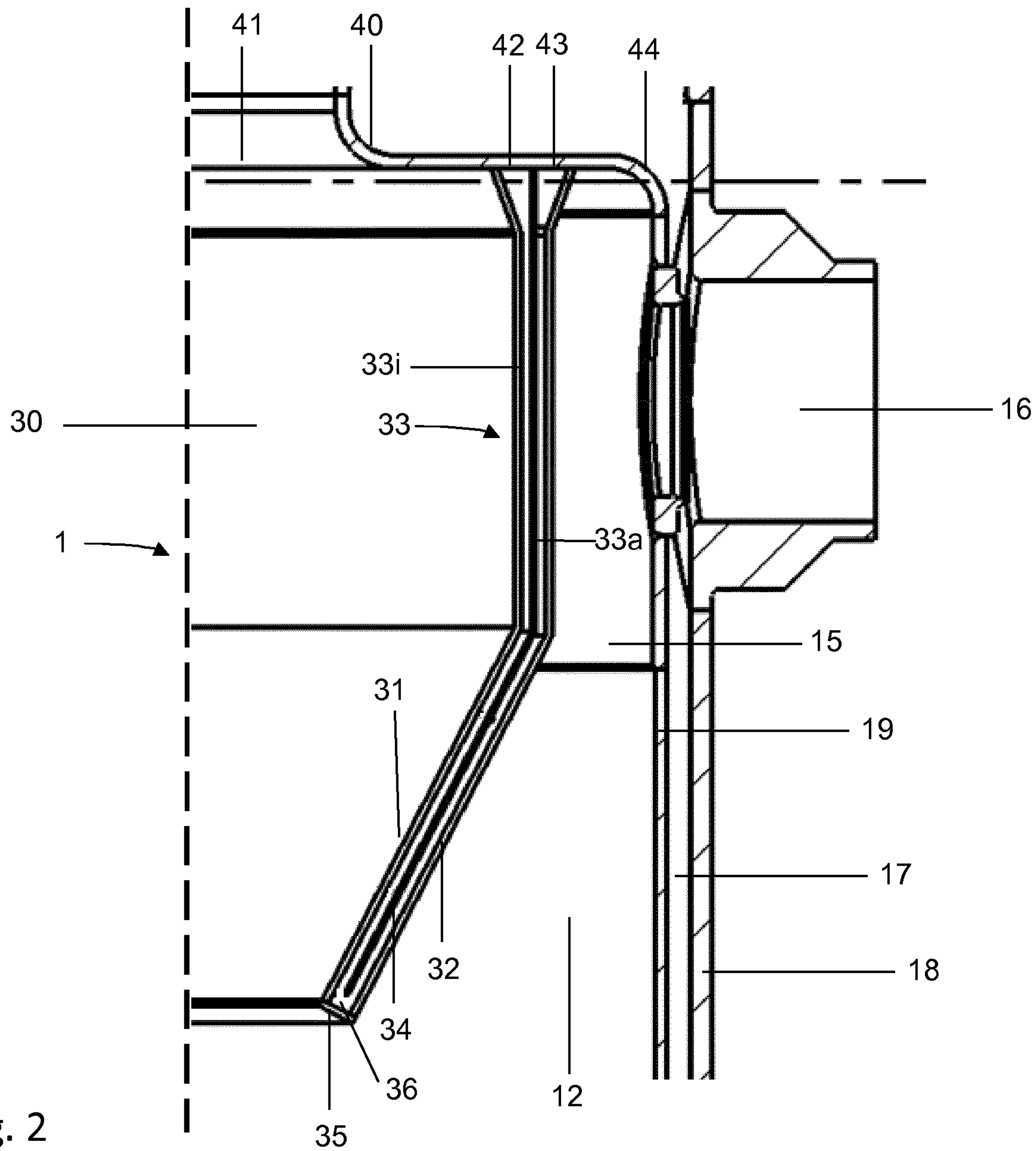

Fig. 2

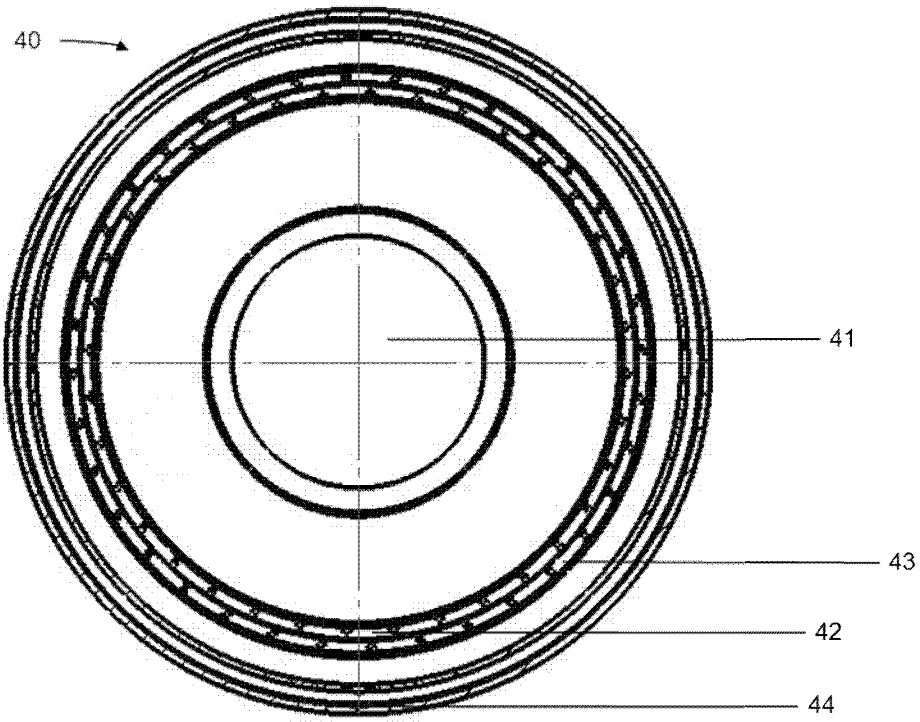

Fig. 3