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Method and apparatus for gasifying solid fuels

The present invention relates to a device according to the pre-characterising part of claim 1 and a method according to the pre-characterising part of claim 8.

The invention accordingly relates to a method and to the devices of an autothermal parallel-flow fixed-bed gasifier operating under a vacuum with internal circulation for producing an almost tar-free wood gas from wood chips or a ligneous biomass for use in engines, which is achieved in particular by optimising the thermochemical process of the gas reduction.

The aim is to raise the continuous production of a wood gas of high quality and quantity by the gas reduction, that ultimately can be used with little effort and expense of a dry gas treatment (dust removal and cooling) in combustion engines for generating steam and heat.

An alternative is also to utilise the wood gas for biodiesel production, e.g. according to the Fischer-Tropsch method. Structural devices for the gas reduction should prevent the problematic formation of tar, in order to be able to avoid a complicated and costly pyrolysis gas scrubber. Using the known technique of hot gas filtration (dry gas purification) the wood gas can be cleaned without great effort in high temperature resistant ceramic filter candles to remove carbon dust, and then when cooled can be burnt in the engine.

By means of the method and the structural devices economic competitive advantages are achieved, in which high investment and operating costs of expensive methods or a pyrolysis gas scrubbing to remove the tar and dispose of pyrolysis residues and the energy loss of the calorific value of precipitated hydrocarbons in the wood gas and also to overcome pressure losses in the system, can be avoided. A greater efficiency can be achieved with this wood gas reduction method compared to other methods.

In order to obtain the maximum amount of gas from the gasifier fuel, fresh gas-rich dried chippings of biomass with a mean particle size of ca. 30 mm to 70 mm and a maximum water content of 20% should be used.

A method of the type described above is known from DE 102 58 640 A, in which a gasification agent is blown into the central region of a fixed-bed reactor and is divided into a first and a second partial stream. The first partial stream removed from the head of the reactor is post-oxidised in an oxidation chamber and then mixed with the second partial stream. The gas mixture thereby obtained is post-treated in a fluidised bed reactor. The method described in this specification is complicated in terms of apparatus and requires, in addition to the fixed bed reactor, a separate oxidation chamber and a fluidised bed reactor. The object of the present invention is to provide a method for the gasification of solid fuels, which has a high efficiency and produces a qualitatively high-grade end product.

From WO 2008/107727 A three-stage pyrolysis reactor is known, in which pyrolysis gas is removed by suction from the head of the reactor, air is blown into the upper third of the reactor, air together with the externally downwardly led pyrolysis gas is blown into the lower third of the reactor, and clean gas is removed from the bottom of the reactor. The construction of this device is relatively complicated, since several blowers are provided in order to move the individual gas streams. Furthermore a complicated temperature management is necessary on account of the outwardly led gas streams. The structure of the reactor is overall relatively high on account of the three-stage nature of the method.

Similar disadvantages are found in the solution as described in US 4 306 506 A. Here too the pyrolysis gases are first of all led outwardly and are subsequently reintroduced into the reactor.

This object is achieved according to the invention by a method having the features of claim 8. In particular such a method is characterised in that via the arrangement of internal vertical side channels in the fixed-bed reactor an internal circulation of the gases is produced by the suctioning of the ascending low-temperature carbonisation and pyrolysis gases formed in the gasification through the diffuser-injector nozzles (injector conveyor) and these are mixed with the gasification agent via the eight-jet nozzle ring in the oxidation zone.

Owing to the intensive turbulence of the gas mixture – similar to an oil burner – there is a complete combustion of the tar-containing raw gases and cracking of the long-chain hydrocarbon compounds in the oxidation zone.

Below the nozzle level at the end of the bottleneck-shaped constriction the arrangement of a spacious trough grate provides for the sufficient formation of a continuous charcoal firebed as reduction zone for the production an almost tar-free wood gas by a complete gas reduction, which afterwards only requires a dry gas treatment.

This method with the structural devices for the internal gas circulation and the intensive diffuser injection of the raw gases into the oxidation zone utilising the injector flow energy for the conveying, mixing and blowing in, and also the continuous charcoal firebed formation in the spacious trough grate as reduction zone largely meets the requirements of ideal conditions of the catalytic and thermal gas formation process for the production of an almost tar-free product gas.

In this parallel-flow gasifier with internal circulation of the pyrolysis and low-temperature carbonisation gases the necessary influencing factors and parameters of the physical and chemical processes according to the Boudouard reaction, the hydrogen reaction and the methane reaction are implemented for a good gas quality and quantity. These are

- the uniform, complete course of the reaction;
- a sufficient residence time of the gases in the reaction zones;
- the optimal temperature distribution in the reactor according to the operating conditions.

The method for the production of wood gas by gasification of biomass from wood is prior art, though the production of an almost tar-free wood gas was hitherto possible only with considerable expense.

The Imbert wood gasifier as fixed-bed reactor served as the basis of all gasifiers operating according to the ascending parallel-flow principle, in which dried lumps of wood and the gasification agent air-oxygen is fed in a sub-stoichiometric amount

through air nozzles through the gasifier for the combustion and oxidation. In this way the wood is generally thermally decomposed into different constituents.

In the decomposition of the wood in the gasification process various temperature zones are established in the fixed bed, which are not separate from one another but in which there is a fluid transition between them.

These temperature zones through which the gasifier fuel/wood chips flows are in general the drying zone at temperatures of up to 200°C, the pyrolysis zone (decomposition, degasification) at temperatures between 200°C – 700°C, the oxidation zone and combustion zone at temperatures of up to 1300°C, and also the reduction zone at temperatures of between 500°C - 600°C.

In order to be able to maintain the energy of the consuming zones for drying, pyrolysis and reduction (endothermic processes), the use of a suitable gasifier fuel consisting of wood chips (lumps, calorific value) and a sophisticated device for the production of already burnable gas constituents (CO_2, H_2) as well as non-combustible gaseous intermediate products (CO_2, H_2O) (exothermic process) are necessary in the region of the combustion (oxidation) for the thermal energy recovery.

In the course of the combustion and oxidation energy is released as heat, which decomposes and degasifies the overlying wood chips and furthermore pre-dries them in the upper region. In the oxidation zone charred wood and charcoal are produced, which forms the reduction zone, where part of the combustion products (CO_2, H_2O) is reduced to further combustible gaseous constituents (CO_2, H_2, CH_4) as a gas mixture.

In the production of the charcoal the volume of the wood chippings is reduced, so that to form a compact reduction zone in the gasifiers a constriction of the reactor is made in the transition region from the oxidation zone to the reduction zone.

The combustible gas mixture generated from the reduction zone is led away and suctioned substantially vertically in parallel-flow through the grate and its slits for

the gas treatment. In this connection the carbon dust together with the resultant wood ash is separated from the gas mixture.

The general problem of parallel-flow fixed-bed gasifier plants of the known method is, as previously, the control of the individual complex processor steps in order to avoid the production of tars and hydrocarbons in the gaseous mixture on account of an insufficient gasification. Also known in this connection are the problems of the accumulation of the ascending tar-containing low-temperature carbonisation and pyrolysis gases in the upper gasifier space and the unsatisfactory solution of a gas treatment.

A further cause of the high amount of unburnt hydrocarbon compounds in the pyrolysis gases is also the operation of large-volume gas reactors with gasifier fuels of different particle size and moisture content. In these reactors the reduction zone is formed undersized in relation to the oxidation and pyrolysis zone, whereby a sufficient gas reduction cannot take place and a complicated and expensive gas treatment is therefore necessary.

For this reason complicated, multi-stage gasification concepts have been developed recently in order to avoid the generally known tar fraction in the product gas. Here the aim is to split up the complex partial gas streams and to bring these into suitable controllable reaction states for producing a pure product gas. This requires a corresponding technical expenditure for the regulation of the gas streams and an additional energy expenditure for the gas treatment at the required high temperature states of 1300°C for the thermal cleavage of the tar constituents.

Thus, in the multistage gasification plant described in DE 102 58 640 A1 the splitting into two partial gas streams is carried out upwardly in the countercurrent method and downwardly from the fixed bed in the parallel-flow method. In order to control the volume ratios throttling devices are employed. The upwardly led partial gas stream is passed through the fuel bed for the separate oxidation into an oxidation chamber and is oxidised in a sub-stoichiometric amount by the addition of combustion air at 1100°C - 1300°C, so as to thereby crack and oxidise the undesired, long-chain hydrocarbon compounds. A second, untreated partial gas stream is led from the fixed-bed gasifier in parallel flow downwards together with

the first hot waste gas from the oxidation chamber and mixed. The downwardly diverted partial gas stream serves at the same time as a transport medium for the required reduction coke in the reduction chamber, which after mixing with the first treated steam-rich gas stream is introduced into the downstream reduction chamber for the joint gas reduction. The pneumatic transportation of the coke is assisted by the feeding of the waste gas from the oxidation chamber, wherein the reduction reactor designed as a fluidised bed forms with the inflowing and coke-containing gas the combustible gas constituents H2 and CO.

This multistage gasification process by separating the gas streams into individual reaction chambers with the aid of the control by throttling devices is very complicated and costly for the cracking and oxidation of undesired long-chain hydrocarbon compounds with subsequent gas reduction, and as is known is employed in fluidised bed gasifiers.

A further method for reducing the tar contents in the product gas is described in EP 0 693 545 A1, where an annular gas channel is provided in the region of the constriction in the gasifier space, in which the obtained gas is subjected to a second combustion in the annular channel. Instead of taking gas from the annular space, the gas should flow through the nozzle ring in the hottest zone at ca. 1000°C in order to be able to burn tar fractions. By means of switching devices the gas can be removed directly from the gasification zone, or by mixing both gas streams, can be removed from the gasifier.

These developments disclose various solutions for the possible reduction of the tar fractions in the product gas, which however are not comparable to the present invention of the fixed-bed parallel-flow gasifier with internal circulation of the raw gases. The technical solution of the known problems of gasification is solved with the invention of the parallel-flow gasifier with internal circulation, in which the ascending tar-rich low-temperature carbonisation and pyrolysis gases, which are formed in the decomposition and degasification by the combustion (oxidation) of the gasifier fuel, are suctioned through the internal vertical side channels in the reactor by means of the diffuser-injector nozzle action (injector conveying technique) in the upper gasifier space.

In this connection the tar-rich low-temperature carbonisation and pyrolysis gases (conveying medium) together with the gasification agent (propellant) are mixed with one another by suctioning through the eight arranged diffuser nozzles and are blown with pressure energy into the oxidation zone in the gasifier for the combustion and energy recovery. Owing to the intensive turbulence of the gas mixture – as in the case of an oil burner – in the oxidation zone there is a complete combustion of the tar-containing raw gases and the cracking of the long-chain hydrocarbon compounds.

The diffuser injection nozzles produce at the same time by the suctioning, mixing and blowing in of the media, a constant internal circulation of the gas streams in the reactor and thus a uniform temperature distribution and a complete course of the thermochemical reactions with a sufficient residence time for the gas reduction.

These reaction and flow processes of the gas above the nozzle level take place in counter current to the path of the fuel flow in the gasifier (region A) and are produced by the release of thermal energy in the feed of the air-oxygen gas mixture (sub-stoichiometric combustion) in the partial oxidation, pyrolysis and drying zones.

The advantages of this method and of the device for the suctioning of the tar-containing low-temperature carbonisation and pyrolysis gases in the upper gasifier space through the injector conveyer of the diffuser-injector blowing nozzles are above all the energy recovery by the complete combustion of the tar-containing gases for the further gas reduction, the prevention of the not harmless gas outflow through the fuel feed opening and the avoidance of additional expenditure for the removal and further gas treatment of the low-temperature carbonisation and pyrolysis gases.

Underneath the nozzle level (region B) there is located at the end of the bottleneck-shaped constriction the device of a spacious octagonal-shaped trough grate for containing a sufficient charcoal fire bed as reduction zone for the gas recovery.

A charcoal fire bed, which is renewed in the gas reduction, is constantly formed in the decomposition, degasification and oxidation (combustion) of the gasifier fuel.

Oxidation products (CO2, H2O) produced in the combustion are drawn by the suction force of the gas engine through this glowing charcoal in the trough grate during the vacuum operation and in parallel flow, and are thereby reduced to combustible gases (CO, H_2, CH_4).

This arrangement of a spacious octagonal trough grate satisfies, as a result of the proportional excess size in relation to the size of the oxidation and pyrolysis zone, the precondition of a complete gas reduction and thus the production of an almost tar-free product gas.

The transition from the oxidation zone to the reduction zone in the region of the bottleneck-shaped constriction ending with the inclined trapezoidal-shaped octagonal trough grate furthermore provides a homogeneous temperature distribution and intensive mixing of the gases, whereby the interactions of the oxidation and reduction reactions for the gas reduction are optimised.

Compared to the multistage gasification plant disclosed in DE 102 58 640 A1, the parallel-flow fixed-bed gasifier with internal circulation of the low-temperature carbonisation and pyrolysis gases differs in that there is no external separation of the gas streams for a separate gas treatment (oxidation-reduction chamber), no throttling devices and no pneumatic transport of coke for a reduction reactor formed as a fluidised bed, but instead all interactions between oxidation and reduction and the complex gas formation processes for obtaining an almost tar-free wood gas in a gasification reactor are optimised.

Also, the wood gas generator according to EP 0 693 545 A1, where in the region of the constriction in the gasifier space an annular gas channel is provided for a combustion of tar fractions, does not correspond to the present invention, since in comparison to this a gas mixture is blown into the oxidation zone through an eight-jet nozzle ring with diffuser-injector nozzles for the complete combustion.

The advantages of this method and the structural devices of the autothermal and pressureless parallel flow fixed-bed gasifier with internal circulation are disclosed according to fig. 1, Fig. 2 and Fig. 3 as follows:

- owing to the suction and mixing of the circulating low-temperature carbonisation and pyrolysis gases with the gasification agent via the injector conveyor of the diffuser-injector nozzles (Fig. 3) and owing to the blowing in of this gas mixture into the oxidation zone, an intensive combustion and oxidation at high temperatures of about 1300°C is achieved, in which a cracking of the tars and undesired long-chain hydrocarbon compounds takes place;

- owing to the diffuser-injector action the drive of the gas circulation is maintained via the at least eight-jet nozzle ring, whereby a uniform temperature distribution and a sufficient residence time of the gases for the complete course of the gas reduction is achieved;

- with the device of a proportionally oversized octagonal trough grate a sufficient amount of glowing charcoal as reduction zone is present, which enables a complete reduction of the oxidation products for the production of an almost tar-free wood gas.

With the method and the technical devices the necessary operating conditions for the interaction between oxidation and reduction and the catalytic and thermal gas formation processes such as the Boudouard reaction, the water gas reaction and the methane reaction can be ensured under favourable conditions, so that virtually no unburnt hydrocarbons and tar distillates are present in the wood gas.

In this way the complex processes of the combustion and gasification in order to produce a product gas of the highest quality and quantity can be implemented, with the aim of a minimum expenditure on a dry gas treatment (hot gas filtration for dust removal) and cooling of the gas for use in engines.

The continuous gasification process of biomass from wood requires on account of the outlined process chains a large number of plant components and process technologies, all of which have to be adapted to one another in order on the one hand to avoid operational malfunctions and on the other hand to achieve maximum efficiencies with the best gas quality and quantity.

The implementation of the process chains of an integrated gasification system is the product of a wood gas power plant system with the following interlinked plant components:
Fuel preparation (chopping, screening), continuous drying, charging of the storage containers and the gasifier, post-combustion or gas flare, dust removal by hot gas filtration, gas cooling, and the generation of electricity and heat in a gas engine cogeneration plant.

The invention of the parallel-flow reduction fixed-bed gasifier reactor with internal circulation consists according to Fig. 1 and Fig. 2 in the construction for servicing reasons (maintenance, repair) of three individual dismantlable construction parts, which are carried by a rectangular steel frame 21 on four suspensions 26.

1. The removable refractory gastight covering 24 of the gasifier with the fastening 23 and the charging device comprising a double gate valve with motor drive 10;

2. The steel jacket as a cylinder vessel 1 with the refractory lining 9 and integrated ventilation channels 6 and also connections for fittings 8;

3. The removable lower part of the reactor 23 with the external annular line 4 and the connection to the eight-jet diffuser-injector nozzles 5 as nozzle ring, in which the gas mixture 22 of pyrolysis gas 7 together with the gasification agent 4 is blown in for the combustion and gasification of the fuel, and the octagonal sloping trough grate 3 with a moveable lower part of the grate for manual or motor operation 12 for containing the charcoal fire bed as reduction zone and also the inclined constricted outflow located underneath as ash chute 13 with motor-driven 19 removal 18 of the ash in the gastight ash pan 20, the moveable grate 3 and also the gas outlet pipes 14, 25.

The pressureless autothermal parallel-flow fixed-bed gasifier reactor space 2 has with the refractory lining 9 a bottleneck shape, comparable to a blast furnace. Owing to this restriction in the transition region from the oxidation zone to the reduction zone there is an intensive mass transfer between the reacting surface of the

charcoal firebed and the gas constituents (CO2, H2O) for the formation of the gas reduction products (CO, H2, CH4).

According to Fig. 1 gasifier fuel consisting of lumpy wood chippings is fed to the largely airtight and backburn-protected double gate valve 10, which is introduced into the reactor space 2 after actuating the paddle 8.

The gasification material runs through the reactor space 2 from the top down through the drying, pyrolysis (decomposition, degasification) oxidation and reduction zones. In the combustion in the oxidation zone temperatures of more than 1200°C are established at the nozzle level in the firebed over the trough gate 3, wherein the released energy maintains the gasification processes in the individual zones. In this connection the resulting low-temperature carbonisation and pyrolysis gases ascend in countercurrent to the upper gasifier space 7.

By means of at least eight uniformly distributed injector nozzles 4, in the form of a diffuser – see Fig. 3 – which are connected to the outer annular pipe 4 around the gasifier reactor 1, the accumulating pyrolysis gases ascending to the gasifier space 7 are suctioned through the injector action via the side channels 6 vertically integrated in the refractory lining 9, and mixed with the gasification agent from the pipes 4, 5 are blown as the gas mixture 22 into the oxidation zone for the joint combustion with the gasifier fuel 2.

Owing to this suctioning of the highly volatile low-temperature carbonisation gases and tar-containing pyrolysis gases 7, which are formed in the drying, decomposition and degasification reactions by the combustion of the ascending gasifier fuels, an internal circulation of the gas streams over the gasifier space is initiated. The through-flow of the gasifier fuel and the circulation of the gas streams of unburnt hydrocarbons promote a uniform temperature distribution in the gasification reactor and in this way intensify the complete course of the equilibrium reactions.

Owing to the suction of the ascending pyrolysis gases in the upper gasifier space 7 through the internal side channels 6 the generally known problem of the undesired escape of gas during the opening for introducing the fuel to the gasifier is solved. The not harmless pyrolysis gases ascending in countercurrent in the upper gasifier

space are generally passed at high cost depending on the method to a gas purification.

After the intensive mixing process between the conveying medium of the low-temperature carbonisation and pyrolysis gas and the propellant of the gasification agent (e.g. atmospheric oxygen) the pressure energy of the diffuser-injector nozzles 5 when blowing the gas mixture 22 into the charcoal firebed brings about an optimal combustion of the gas mixture and cracking of the tar-containing low-temperature carbonisation and pyrolysis gas. The sub-stoichiometric addition of combustion air leads to the energy recovery with a high rise in temperature (exothermic process) to about 1100°C to 1200°C, whereby a comprehensive cracking and conversion of the unburnt hydrocarbons to the chemical constituents (CO2, H2O) is achieved.

In order to increase the efficiency the gasification agent is blown preheated through at least eight uniformly distributed air nozzles 5 into the centre of the reactor, the nozzles being connected as a nozzle ring around the gasifier to the external annular line 4.

A spacious grate in the form of an octagonal trough 3 with inclined side walls is placed in the middle of the reactor vessel underneath the blowing-in nozzles, in which a charcoal firebed is constantly formed as a reduction zone or as catalyst for the gas reduction.

The product gas formed in the reduction zone (exothermic process) leaves downwardly through the slit-shaped refractory openings of the trough grate 3 in the prevailing vacuum operation, which is produced by the suction motor and waste gas fan.

The product gas leads via the refractory opening 14 to the side gas outlet pipes 25 of the gasifier and is fed to a gas purification and cooling unit before being used in the motor heating power plant .

When the product gas flows through the charcoal firebed the wood ash formed in the combustion and in the gas production and also the dust-containing and coarse

grained charcoal are entrained as dust. The coarse grained charcoal dust together with ash falls in the sloping part of the ash shoot 13 located under the reactor. The ash and the coarse grained charcoal dust is conveyed via a screw 18 driven by a motor 19 to the gastight ash pan 20 and is disposed of.

In order to remedy malfunctions in the charcoal bed due to slag or ash accumulations the flat lower part of the octagonal trough grate 3 can be moved by a motor 12 or manually.

In order to screen against penetration of gasifier material 2 the side channels 6 are protected by coverings 16, and also the gas outlet opening 14 of the gas outlet pipe 25 is protected against the penetration of ash and carbon soot by a covering 15.

The configuration of the steep bottleneck shape of the internal gasifier space 2 due to the refractory lining 9 prevents the otherwise feared bridge formation or cavity formation due to burnout, since the gasifier fuel rests directly on the octagonal trough grate 3 for the combustion and gasification and will inevitably slip due to gravity. Also, when the particulate gasifier fuel is introduced through the double gate valve 10 there is an additional drop in pressure, whereby bridge formations and cavity formations are prevented.

The bottleneck-shaped constriction over the trough grate also produces an intensive change of material flow, which makes possible a homogeneous temperature distribution with the pyrolysis gas and gasification agent gas mixture and the glowing charcoal as reduction zone, and also a further cracking of residual tars.

The internal circulation of the gas streams for the cracking of the hydrocarbons and tars in addition improves this process. In this way it is possible to achieve an optimal temperature distribution in the reactor with a uniform complete course of the reactions and also a sufficient residence time of the gases in the reaction zones. These are the optimum preconditions for establishing the reactions according to the Boudouard, water gas and methane reactions for the production of a good gas quality and quantity.

Some essential aspects of the present invention are summarised hereinafter in the form of an overview. An essential feature is that the device of the reactor vessel 1 consisting of a cylindrical steel sheet jacket, a bottleneck-shaped refractory lining 9 of the gasifier space 2 with vertical side channels 6, an annular pipe 4 around the gasifier, implemented as an eight-jet nozzle ring with uniformly distributed diffuser-injector nozzles 5 (injector conveyor) for suctioning the low-temperature carbonisation and pyrolysis gases 7 (conveying medium) by means of the gasification agent 4 (propellant medium) and production of a gas mixture 22 of both media and the blowing of the gas mixture (diffuser-pressure energy action) into the oxidation zone, a double gate valve 10 for introducing the gasifier fuel into the gasifier space 2, which is combusted and gasified in the drying, pyrolysis and oxidation zones, and in the octagonal, trapezoidal trough grate 3 a charcoal firebed is constantly reformed as a production zone for the gas production by sub-stoichiometric combustion of the gasifier fuel, is the basis of the method, in which by suctioning the ascending low-temperature carbonisation and pyrolysis gases from the gasifier space 7 above the vertical side channels 6 of the refractory lining 9 of the reactor and by the injection 5 of the thereby formed gas mixture 22 with the gasification agent 4 through the diffuser-injector nozzles (Fig. 3), an internal circulation of the gases in the reactor is necessarily produced, which simultaneously with the injection into the oxidation zone with the action of the diffuser-ejector nozzles 5 produces an intensive turbulence of the gas mixture 22 and thus leads to a complete combustion of the tar-containing gas mixture 22 and the cracking of the tars and long-chain hydrocarbon compounds.

Furthermore it is essential that with the device of the injector conveyance, Fig. 3, implemented as the blowing-in/jet nozzle 5 (propellant, gasification agent), the low-temperature carbonisation and pyrolysis gases 7 (conveying medium) are suctioned under the action of the vacuum and the thereby formed gas mixture 22 (gasification agent and conveying medium) in the diffuser 5 is injected with compression energy into the oxidation zone and an internal circulation of the gases through the individual drying, pyrolysis and oxidation zones is thus initiated by the injector conveying action, gas escape during the addition of fuel is avoided, and at the same time, owing to the intensive combustion together with turbulence, a homogeneous temperature distribution and also intensive mixing of the gases in the reactor, and

a sufficient residence time of the gases for the further cleavage of the unburnt hydrocarbon compounds and tars are achieved.

A further important feature is that the device of a nozzle ring 4, 5 (Fig. 2) is arranged uniformly distributed around the gasification reactor with at least eight injector blowing-in nozzles 5, which is connected to an annular line 4 disposed externally around the reactor and guides a centrally connected preheated gasification agent, in which the gas mixture 22 together with the low-temperature carbonisation and pyrolysis gases is blown into the middle of the oxidation zone in the gasifier and by means of this arrangement a controllable safety technology is ensured.

It is particularly preferred if the device consisting of a spacious octagonal sloping trapezoidal refractory grate with slit openings in the form of a trough 3 is arranged centrally in the middle of the gasification reactor, which has a lower part of the refractory grate that is moveable by hand or motor 12 for rectifying malfunctions caused by slag and ash accumulations, in which compared to the oxidation and pyrolysis zone a proportionately oversized amount of a glowing charcoal firebed as reduction zone is arranged upstream, which is constantly renewed by sub-stoichiometric combustion of the gasifier fuel and thus as catalyst enables a largely complete gas reduction of the oxidation products (CO_2, H_2O) for the production of an almost tar-free product gas (CO, H_2, CH_4).

Furthermore it is advantageous if the device consisting of an ash chute 13 in the lower part of the gasifier underneath the trough grate 3 fulfils the object of holding the ash and carbon dust, which after the combustion of the gasifier fuel in the trough grate 3 and due to the abrasion caused by the suction of the product gas in the vacuum operation falls through the slit-shaped trough grate 3 onto the ash chute 13 lying underneath and is constantly removed via a motor-driven 19 ash screw 18 and deposited in the gastight ash pan 20.

It is recommended if with the device a largely airtight, motor-driven double gate valve 10 protected against burnback carries out the charging of the gasification reactor with gasifier fuel, which is mounted on the detachable covering 23, 24 of the steel cylinder and the lower gate valve is screened by a refractory, moveable plate 11 against radiation from hot gases.

Furthermore it is advantageous if the device for the gasification reactor, Fig. 1, can be dismantled for servicing and technical reasons into three structural components, namely an upper part with the covering 24 and double gate valve 10, a middle part consisting of a steel sheet cylinder ring 1 with a refractory lining 9 of bottleneck shape 17 and integrated vertical side channels 6, and a lower part in which the diffuser-injector nozzles 5 together with the annular pipework 4, the octagonal trough grate 3, the connected ash chute 13 with gas outlet pipes 14, 25 and ash removal device 18, 19, 20 and all constituents together form one unit.

A further aspect of the invention is that the device of the inner lining 9 of the reactor space is executed in the shape of a bottleneck,
in which the vertical side channels for the internal circulation of the gases under vacuum operation are integrated, and sits over the octagonal trough grate 3 and thereby produces an intensive change of material flow for a homogenous temperature distribution, which prevents a bridge formation and the burnout of cavities.

Furthermore it is important that the device for the gasification reactor 1 (Fig. 1, Fig. 2) is for service and technical reasons uniformly fixed and supported on a rectangular steel frame 21at four points 26 and on which the items of technical equipment are fastened.

Lastly and in summary the invention relates to an autothermal fixed-bed parallel-flow gasifier operating under vacuum with internal gas circulation for producing an almost tar-free wood gas from biomass with the devices according to Fig. 1, a reactor space 2 with a bottleneck-shaped lining 9 and integrated vertical side channel 6, a double gate valve 10 for introducing the gasifier fuel and an injector conveyor consisting of an at least eight-jet diffuser-injector nozzle crown 4, 5 for suctioning and mixing the low-temperature carbonisation and pyrolysis gases 7 with the gasification agent 5, whose gas mixture 22 is blown under pressure into the oxidation zone, the nozzle ring with an annular pipeline connected externally around the gasifier supplied with preheated gasifier agent, and a proportionally oversized octagonal trough grate 3 for holding the charcoal firebed as a reduction zone for a sufficient gas reduction.

The method of the internal circulation of the low-temperature carbonisation and pyrolysis gases 7 with the combustion agent 4 through the suction, mixing and blowing of the gas mixture by the injector conveyor into the oxidation zone for the joint combustion with the gasifier fuel is based on the principle of these devices, whereby a cracking of the tars and hydrocarbons, a uniform temperature distribution, and a sufficient residence time for a complete gas reduction in the reduction zone in the spacious trough grate are ensured.

Patentkrav

1. Indretning til forgasning af faste brændstoffer, især af biomasse, i form af en autotermisk jævnstrøms-fixed bed-gasgenerator der fungerer ved undertryk, med en fixed bed-reaktor der har et reaktorkammer (2) med et øverste afsnit (2a) som en oxideringszone og et nederste afsnit (2b) som en reduceringszone, hvor der er tilvejebragt diffusorinjektionsdyser (5) til at injicere forgasningsmiddel (4), der er indrettet mellem det øverste afsnit (2a) og det nederste afsnit (2b) i et midterområde af reaktorkammeret (2), og hvor mindst en øverste udløbsåbning er tilvejebragt i det øverste afsnit, der er forbundet med mindst en returforsyningsåbning (22) i midterområdet af reaktorkammeret (2), hvor diffuserinjektionsdyserne (5) til at injicere forgasningsmiddel fører til den mindste ene returforsyningsåbning (22), og mindst en nederste udløbsåbning er tilvejebragt i det nederste afsnit, **kendetegnet ved at** den mindst ene øverste udløbsåbning er forbundet med den mindst ene returforsyningsåbning (22) i midterområdet af reaktorkammeret (2) via indvendige vertikale sidekanaler i fixed bed-reaktoren; og den øverste udløbsåbning udelukkende er forbundet med den mindste ene returforsyningsåbning (22).

2. Indretning ifølge krav 1, **kendetegnet ved at** diffuserinjektionsdyserne (5) er indrettet til at være jævnt fordelt rundt om omkredsen af reaktionskammeret i form af en dysering.

3. Indretning ifølge et hvilket som helst af kravene 1 eller 2, **kendetegnet ved at** det nederste afsnit af reaktionskammeret er formet som en fortrinsvis ottekantet karrist (3).

4. Indretning ifølge et hvilket som helst af kravene 1 til 3, **kendetegnet ved at** den øverste udløbsåbning er forbundet med den mindst ene returforsyningsåbning (22) via sidekanaler (6) der er indrettet indeni en cylinderformet stålpladekappe og uden for en brandsikker udmuring (9).

5. Indretning ifølge et hvilket som helst af kravene 1 til 4, **kendetegnet ved at** en askeskakt (13) der skal modtage rester i fast form er indrettet under karristen

(3), idet askeskakten er forbundet med en gastæt askebakke (20) via et asketransportbånd (18).

6. Indretning ifølge et hvilket som helst af kravene 1 til 5, **kendetegnet ved at** brændstofforsyning af reaktorkammeret (2) sker via en dobbelt skydeventil (10).

7. Indretning ifølge et hvilket som helst af kravene 1 til 6, **kendetegnet ved at** en udmuring (9) af reaktorkammeret (2) har form som en flaskehals.

8. Fremgangsmåde til forgasning af faste brændstoffer, især af biomasse, i en autotermisk jævnstrøms-fixed bed-gasgenerator der fungerer ved undertryk i følge et hvilket som helst af kravene 1 til 7, hvor et forgasningsmiddel, fortrinsvis luft, injiceres i et midterområde af et reaktorkammer (2) af en fixed bed-reaktor og hvor en første delvis strøm af den injicerede gas ledes opad i en modstrøm og fjernes fra fixed bed-reaktoren som en pyrolysegas (7) og hvor en anden delvis strøm af den injicerede gas ledes nedad i en jævnstrøm og fjernes fra fixed bed-reaktoren, **kendetegnet ved at** den første delvise strøm (7) ledes nedad i fixed bed-reaktoren uden for reaktorkammeret (2) via indvendige vertikale sidekanaler og genindføres i reaktorkammeret (2) sammen med forgasningsmidlet (4), hvor den første delvise strøm returneres til fixed bed-reaktoren gennem injektionsvirkningen af forgasningsmidlet (4) og hvor diffuserinjektionsdyserne skaber en konstant, indvendig cirkulation af gasstrømmene i reaktoren via sugning, blanding og injektion af midler.

9. Fremgangsmåde ifølge krav 8, **kendetegnet ved at** pyrolysegassen (7) fra den første delvise strøm returneres fuldstændigt til fixed bed-reaktoren.

10. Fremgangsmåde ifølge et hvilket som helst af krav 8 eller 9, **kendetegnet ved at** forgasningsmidlet (4) forvarmes inden injektion i fixed bed-reaktoren.

Figure 1

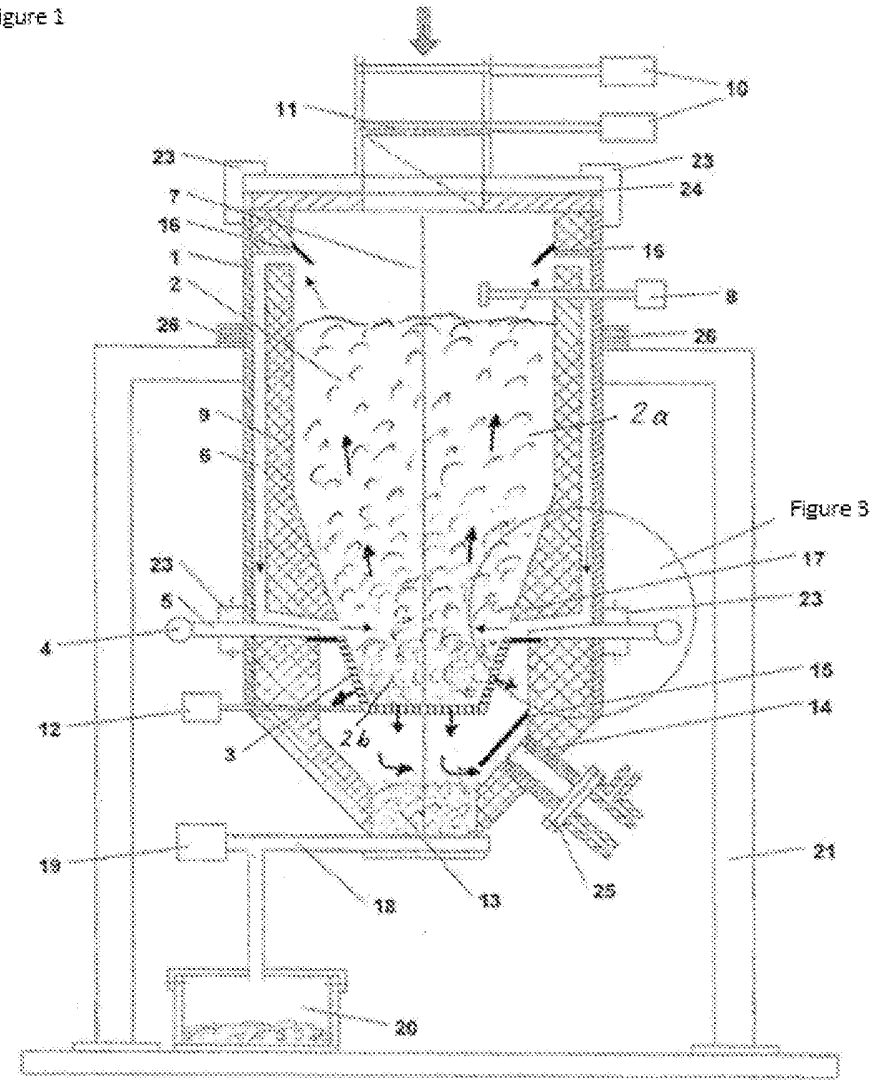
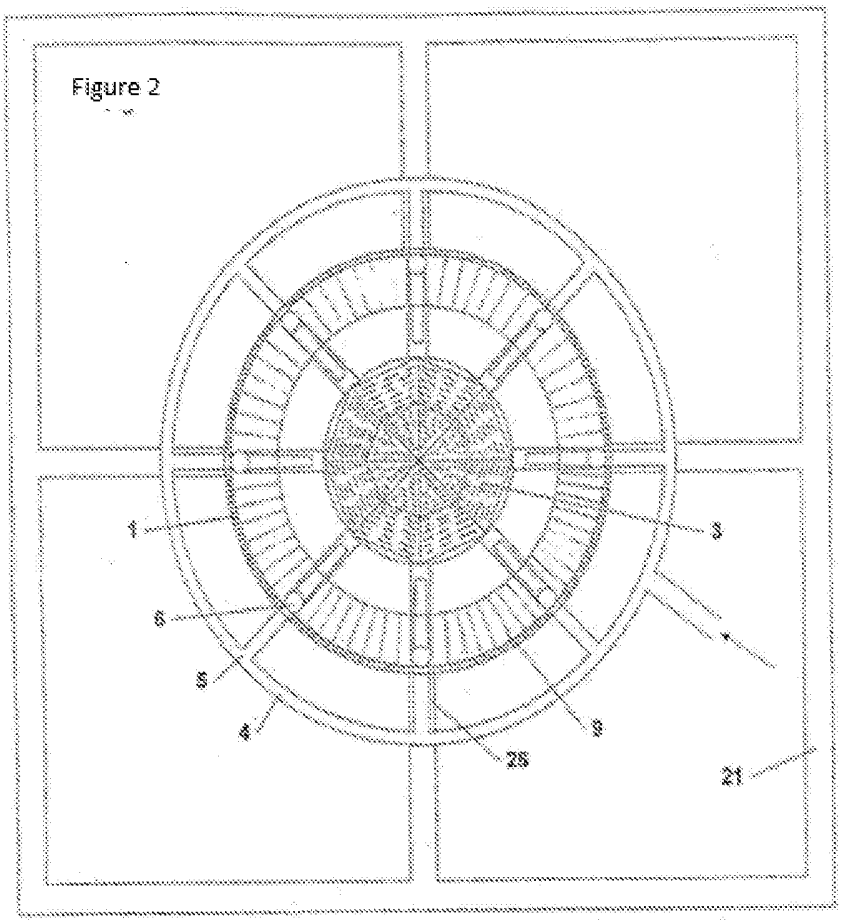


Figure 3

Figure 2



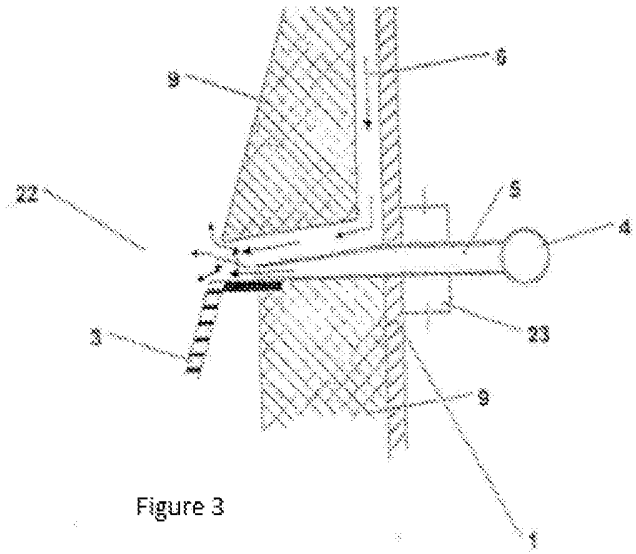


Figure 3