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CARBONIZATION METHOD AND DEVICE

The invention relates to a method for manufacturing charcoal and/or activated charcoal from a load of wood.

The invention also relates to a furnace module for manufacturing charcoal and/or activated charcoal, by carrying out this method, designed able to receive, at a carbonization chamber, a basket designed able to receive a load of wood, said carbonization chamber being arranged between an upstream chamber and a downstream chamber, said furnace module including or being connected to at least one heating means outside said load designed able to generate first nonoxidizing hot heating gases.

The invention further relates to a carbonization installation, in particular for manufacturing charcoal and/or activated charcoal according to such a method, including several such furnace modules.

The present invention falls within the field of the manufacture of charcoal from lignocellulosic materials with any moisture level.

In order to carbonize wood, one raises, in a known manner, the temperature of a load of wood. At a certain stage corresponding to a certain temperature level in the load, a pyrolysis reaction is initiated. Once the pyrolysis reaction is completed, the product resulting from the reaction is charcoal. It is also possible to increase the temperature of the load so as to obtain a more cooked charcoal. Next, the heating means is stopped, and the load of charcoal is cooled.

The carbonization devices can be classified by their heating means:

- partial combustion furnaces are generally artisanal; part of the load of wood is burned to carbonize the rest of the load.
- external heating furnaces use an additional energy source.
- hot gas contact furnaces are compromises between the preceding models, and are in particular used in continuous industrial furnaces.

The state of the art is imperfect, since many problems are not correctly resolved. It is difficult and costly to use green or wet wood. As a result, it is often necessary to dry, upstream from the manufacturing of the charcoal, the wood or scraps from forest or sawmill operations, for 3 to 6 months. This drying is often done in a dryer or a separate furnace, which requires an important energy expenditure.

The small dimensions of the existing furnaces make it necessary to precut the load into small pieces, in particular for continuous industrial furnaces.

For the artisanal furnaces, the carbonization device is immobilized to cool the charcoal, which extends the cycle time by 2 to 12 days depending on the size of the furnace.

The monitoring of the process is done by an operator, and consists of subjective, olfactory and visual monitoring of the smoke. In some industrial installations, temperature sensors make it possible to monitor the process.

The current furnaces do not allow a homogeneous inspection of carbonization temperatures during the process. Indeed, parts of the furnaces exist that are much hotter than desired, and others that are colder. The resulting charcoal is very nonhomogeneous, which reduces the quantity of charcoal obtained and is detrimental to the desired quality.

Many methods require handling the charcoal during its carbonization and/or cooling, increasing the level of fines, which are small and have a low value.

Various devices have tried to resolve these problems. Thus known, from document FR 2,604,181, is a furnace for manufacturing charcoal in a container basket in which hot gases circulate, at a temperature below 400°C, through the load from top to bottom.

Document FR 2,586,031 describes a device with several chambers, each corresponding to a step of the charcoal manufacturing method: drying, carbonization, ventilation, and each equipped with two boilers. The combustion air is brought in by a fan.

A document EP 330,784 describes furnaces operating in pairs: one is used for carbonization, and the hot gases produced during the reaction are led to the other furnace, which is used to dry the wet or green wood.

Known in fields different from that of wood carbonization are installations reusing, at least partially, gases resulting from the reaction in the installation. Thus known is document GB 1,440,236, describing a furnace for processing waste by incineration operating in a continuous loop: distillation gases resulting from the reaction in the chamber of the furnace are, after a necessary purification, which makes it possible to reinject tar and impurities to be reprocessed, separated into two gas portions that follow separate circuits. The first portion necessarily undergoes a washing treatment, then is injected as fuel into a reheating furnace before being sent back into the atmosphere. The second portion is reheated by exchange in this preheating furnace, without contact with the gas flow from the first portion, then reinjected into the incineration furnace. This method absolutely requires purification and/or washing treatments of the gases to allow them to be used. The installation is complex, it includes separate gas circuits, and the gas temperatures is difficult to regulate. No arrangement takes into account, for a carbonization treatment, the need to inject a gas free of oxygen in gaseous form O_2 into the load. Such a furnace is not usable to carry out a carbonization process.

Document WO 02/48292 describes a continuous process for gasification of carbonaceous waste, brought, in a chamber, to a very high temperature (1300°C) in the presence of steam and carbon dioxide. A portion of the pyrolysis gases resulting from the reaction is used directly as fuel. Except for the possibility of injecting fuel, in particular for startup, there is no possibility for regulating the gas for reuse. Furthermore, the latter is only reused by its mandatory combustion.

Such installations, provided for the incineration of waste, are poorly suited to the carbonation of wood, which is a delicate process during which it is necessary to manage an incomplete combustion of a load of wood, while avoiding any seizing of the furnace used to that end, and therefore to monitor the temperature within that load at all times.

In the existing carbonization furnaces, the occupancy duration of the furnaces remains long, which requires placing several furnaces in a battery to perform the drying, carbonization and cooling operations of the load.

Document US 2,705,697 A describes a furnace module for manufacturing charcoal, designed able to receive, at a carbonization chamber, a grate designed able to receive a load of carbonaceous material, said carbonization chamber being arranged between an upstream chamber and downstream chamber, said furnace module including or being connected to at least one heating means, outside said load designed able to generate nonoxidizing hot heating gases.

The invention aims to offset the drawbacks of the state of the art by proposing a particular method for carrying out the carbonization method, from green or wet wood, in a furnace module designed for that purpose, making it possible to reduce the occupancy time thereof, and to obtain a good rotation of the loads, with a good energy efficiency.

The invention also proposes to provide the conditions for regulating a good carbonization reaction within a load of wood, by controlling the flows and temperatures of different gases used. The invention uses the gases circulating in the device to carry out the process, by performing an appropriate mixture of the different gases present at different points of the installation, to bring, upstream from the load, entering gases with the best parameters to initiate and/or maintain the carbonization reaction with an optimal yield, in particular by an optimal control of the distribution of the temperature in the load of wood, and the production of a charcoal of excellent quality.

The invention uses the gases present at the different points of the installation, as is, without performing a purification, wash, or similar treatment, so as to make the device as simple as possible. The invention also, as much as possible, prevents the combustion of the reused gases.

To that end, the invention relates to a method for manufacturing charcoal and/or activated charcoal, from a load of wood according to claim 1.

The invention also relates to a furnace module for manufacturing charcoal and/or activated charcoal, by carrying out this method, according to claim 9.

The invention further relates to a carbonization installation, in particular for manufacturing charcoal and/or activated charcoal, according to such a method, including several such furnace modules, said installation including at least one central furnace generating heating gases for at least two furnace modules that are connected to it.

Other features and advantages of the invention will emerge from the following detailed description of non-limiting embodiments of the invention, in reference to the appended figures, in which:

- figure 1 is a schematic, partial sectional view of a device for carrying out the invention;
- figure 2 similarly shows the device of figure 1 during the beginning of a first startup phase of the method according to the invention;
- figure 3 similarly shows the device of figure 1 during the continuation of this first startup phase of the method according to the invention;

- figure 4 similarly shows the device of figure 1 during a second carbonization phase of the method according to the invention;
- figure 5 similarly shows the device of figure 1 during a third cooling phase of the method according to the invention.

The invention more particularly relates to a method and a furnace module 100 for manufacturing charcoal and/or activated charcoal from a load of wood 6. A first embodiment of the invention is illustrated in the figures.

The invention carries out an innovative method for manufacturing charcoal and/or activated charcoal, from a load of wood 6 arranged in a carbonization chamber 25, and the particularity of which is the initiation, by at least one heating means outside the load 6, or outside a furnace module 100 into which this carbonization chamber 25 is integrated, of a pyrolysis front 20, followed by the controlled propagation of this pyrolysis front 20. To that end, the method includes the following steps:

- using at least one heating means outside the load 6 to generate first nonoxidizing hot heating gases G1, i.e., not including oxygen in gaseous form O_2; to that end, a reducing boiler is preferably used, consuming gases depleted in oxygen in gaseous form O_2 and delivering, as output, gases that do not contain any;
- these first hot heating gases G1 are mixed with second so-called dilution gases G2, to form a mixture of nonoxidizing entering gases G0, not including oxygen in gaseous form O_2;
- this mixture of entering gases G0 is sent upstream into the load 6 to generate a pyrolysis front 20 therein;
- an overpressure is created between the upstream and downstream directions of the load 6 in order to force said pyrolysis front 20 to pass through it in a single direction from upstream to downstream;
- downstream from the load 6, at a downstream chamber 19, third so-called exiting gases G3 are recovered in a pipe 21, gas G2 whereof at least a first part is conveyed in the form of a stream of said second dilution gases G2 by a conveying means 4, and a second part of which made up of so-called

service gases G4 complementary to the first part made up of said dilution gases G2 is discharged, in the form of a flow of these fourth service gases G4, by a conveying means 8 toward an outlet or usage orifice, for example to fill canisters for a reuse of these service gases G4, or to supply another installation, such as a dryer or the like.

In another preferred embodiment of the invention, the wood and/or forest or sawmill operating products, or other plants, which will be called “wood” in the remainder of the description, are stored to form a load 6 in at least one basket 7 allowing the circulation of the gaseous and/or liquid fluids through the load 6. They will remain in this basket 7 throughout the entire duration of the carbonization and cooling operation after carbonization strictly speaking. This basket 7 containing a load of wood 6 can be used as a preparation as well as storage pallet, both for raw material and finished product. This basket 7 can be very large, for example several meters long. This basket can in particular be filled directly in the forest. It makes it possible to process loads that are heterogeneous in terms of essence, moisture level and dimensions. This basket can be positioned with various orientations, and not necessarily vertical or horizontal, even if these are preferred embodiments of the invention.

The method according to the invention then comprises the following steps:

- the load 6 is arranged in at least one basket 7 in a sealed device between a first upstream chamber 18 and a second downstream chamber 19;
- first hot heating gases G1 are generated by at least one heating device outside the load 6, which are brought into a mixing chamber 15;
- second dilution gases G2 are brought into the mixing chamber 15;
- circulation means 5 are used to send a mixture of entering gases G0 made up of said first heating gases G1 and second dilution gases G2 into the first upstream chamber 18 in overpressure relative to the second downstream chamber 19, to generate, in the load 6, a pyrolysis front 20 that is forced, under the action of said circulation means 5, to pass through it in a single direction from the first upstream chamber 18 toward the second downstream chamber 19;

- in the second downstream chamber 19, third exiting gases G3 are recovered;
- at least part of the third exiting gases G3 is recovered, in the form of a stream of second dilution gases G2 that is conveyed by conveying means 4 toward the mixing chamber 15.

Advantageously, the stream of second dilution gases G2 is conveyed by the conveying means 4 toward the mixing chamber 15 separately from the first hot heating gases G1.

In order to reduce the cooling time of the load after the completion of the carbonization cycle, cooling of the load 6 is advantageously done after complete pyrolysis by spraying water in the stream of the mixture of entering gases G0.

In order to draw all of the advantages from the mastery of the carbonization method within the load, one regulates the flow and temperature of the entering gases G0 and controls a gas loop, by monitoring the flows of heating gases G1 and dilution gases G2, this monitoring of the flows being designed able to control the temperature of the entering gases G0, and one further monitors the flow rate of the entering gases G0 by the circulation means 5.

Economically, the method according to the invention does not perform any treatment on the exiting gases G3 other than a potential discharge of condensates, to the exclusion of any washing, combustion, oxidation, heating or cooling, compression or expansion treatment.

Preferably and advantageously, the pyrolysis front 20 is generated and made to progress in the direction opposite the natural convection that is established in the load 6 of wood, which amounts to saying that the entry of the gases upstream in the load 6 preferably has an altitude greater than or equal to the exit of the gases downstream from this load.

To guarantee the introduction of entering gases G0 free of oxygen, the first nonoxidizing hot heating gases G1 are generated at a central reducing furnace in which an incomplete combustion is produced such that the first heating gases G1 are free of oxygen in gaseous form O_2. This central furnace is preferably designed able to supply several carbonization chambers, each of which includes a different charge 6, and subject to a carbonization process different from that of the other charges 6 supplied by entering gas mixtures using this same central furnace.

In an embodiment variant, as shown in the figures, in order to discharge the air introduced with the load 6 during its loading, the portion of the exiting gases G3 that is not used to form the dilution gases G2, is steered toward means for discharge and placement in the atmosphere 17, in particular in the form of a chimney, and/or toward conveying means 16 where this portion constitutes service gases G4 able to supply combustion means such as a furnace, or a dryer, or supplying any other use, either directly, or through a packaging of said service gases in canisters or the like.

In one particularly advantageous embodiment of the method according to the invention, making it possible to obtain a better yield, the pyrolysis is done under pressure, and to that end a first upstream chamber 18 directly upstream from the load 6 as well as a second downstream chamber 19 directly downstream from the load 6 are subjected to a pressure greater than the atmospheric pressure. While this pressure can be very slightly above the atmospheric pressure, with an overpressure in the chambers of around several thousand Pa, it is advantageously chosen with a value of between 10.10^5 and 30.10^5 Pa.

The invention is particularly well suited for the carbonization of eucalyptus, or coconut shells, or other similar tropical plants.

The invention also relates to a furnace module 100 according to claim 9 designed for the implementation of the method according to claim 1.

This furnace module 100 can be mobile. The charcoal obtained *in situ* is about four times lighter than wood. This mobility makes it possible to lighten the transport cost.

This furnace module 100 designed to manufacture charcoal and/or activated charcoal, by carrying out this method, is designed able to receive, at a carbonization chamber 25, a basket 7 designed able to receive a load of wood 6. This carbonization chamber 25 is arranged between an upstream chamber 18 and a downstream chamber 19.

The furnace module 100 can include at least one heating means outside the load 6, designed able to generate first nonoxidizing hot heating gases G1. This heating means can also be outside the furnace module 100, to which it is connected.

According to the invention, the furnace module 100 includes, upstream from the upstream furnace module and communicating with it, a mixing chamber 15 designed able to receive, on the one hand, these first hot heating gases G1, and on the other hand, second dilution gases G2 coming from conveying means 4 communicating with the downstream chamber 19, to form a mixture of entering gases G0.

This basket 7, or a housing 22, included by the furnace module 100 between the upstream chamber 18 and the downstream chamber 19 and which is designed able to contain the basket 7, is designed able to prohibit any passage of the entering gases G0 outside the load 6 except in the upstream chamber 18. The furnace module 100 also includes circulation means 5, designed able to send the mixture of entering gases G0 in overpressure into the upstream chamber 18 relative to the downstream chamber 19.

The furnace module 100 includes means for controlling and regulating the flow and temperature of the entering gases G0, designed able to act on the one hand to control the temperature of the entering gases G0. To that end, they act on flow distributing means 131, in particular for closing, such as gates or registers, located on the path of the heating gases G1, on flow distributing means 132 located on the path of the dilution gases G2, on flow distributing means 134 on a pipe 16 on the path of a part made up of useful gases G4 of exiting gases G3 from the load 6, the other complementary part of the exiting gases G3 making up the dilution gases G2.

These means for controlling and regulating the flow and temperature of the entering gases G0 are also designed able to act on the other hand on circulation means 5 designed able to generate a positive pressure differential between the upstream chamber 18 and the downstream chamber 19 to monitor the flow rate of the entering gases G0. These control and regulating means are further designed able to command the operation of a furnace generating the heating gases G1.

Preferably, the furnace module 100 includes a base 3 able to receive at least one such basket 7 and a lid 1 designed able to be placed above each basket 7, tightly on the base 3. This basket 7 is designed able to receive a load of wood 6, and is arranged between an upstream chamber 18 and a downstream chamber 19.

Advantageously, the furnace module 100 includes a hatch 17, placed tightly on the leg 1, and which is able to open and close to offset any possible gas explosions during the carbonization for the case where an accidental oxygen entry occurs.

Preferably, the basket 7 is open or perforated at both of its ends, to allow the passage of gases and liquids. These ends communicate, one with the upstream chamber 18 and the other with the downstream chamber 19. The basket 7 is then closed tightly with respect to gases on its other sides.

In an embodiment variant, when, preferably but not necessarily, a relative sliding movement is provided of the basket 7 in a housing 22. Although this makes the embodiment more delicate due to the sealings to be provided, the basket 7 can then be entirely perforated, as long as its housing 22 is gas-tight.

Unlike the prior art of partial combustion methods where part of the load 6 is burned, which can then require pre-drying, to facilitate the temperature increase of the load of the furnace, before the closing of the oxygen, according to the invention, entering gases G0 are circulated through the load 6 that is in the basket 7, at a regulated temperature.

The nonoxidizing heating gases G1 are preferably the result of the incomplete combustion of service gases G4. Advantageously, these service gases G4 are recovered downstream from the load 6, or from the load 6 of another adjacent furnace 100.

According to the invention, the mixing chamber 15, located upstream from the upstream chamber 18 and in communication therewith, is able to receive, on the one hand, the first hot heating gases G1 coming from the heating means, and on the other hand, second dilution gases G2, coming from conveying means 4 that communicate with a pipe 21 downstream from the downstream chamber 19. The latter is designed to collect exiting gases G3 coming from the carbonization of the load 6. The conveying means 4 transport at least part of the exiting gases G3, called dilution gases G2, toward the mixing chamber 15 separately from the heating gases G1. The heating G1 and dilution G2 gases are mixed in this mixing chamber 15, to form a mixture of entering gases G0.

A portion of the exiting gases G3 is discharged in the form of a service gas stream G4 through at least one channel 16, in particular under the effect of the pressure of the gases produced by the pyrolysis. The complementary part derived from the exiting gases

G3, called dilution gases G2, circulates in conveying means preferably formed by a bypass pipe 4. The dilution gases G2 arrive separately from the first hot heating gases G1, toward the mixing chamber 15.

The fourth service gases G4 discharged by the pipe 8 represent the excess of the exiting gases G3 in the gas loop produced by the embodiment of the invention.

The furnace module 100 also includes circulation means 5, designed able to send the mixture of incoming gases G0 in overpressure into the upstream chamber 18 relative to the downstream chamber 19. These circulation means 5, which also perform the mixing of the mixture of incoming gases G0, and are preferably made up of at least a turbine or a fan, are dimensioned so as to be able to maintain a sufficient pressure to push the pyrolysis front 20, in a single circulation direction, through the charge 6, from the upstream chamber 18 toward the downstream chamber 19. The energy is therefore extracted from the mixing chamber 15 via the circulation means 5, which impose a circulation speed in the furnace, through the load 6. During the pyrolysis phase, once steam is extracted from the layer furthest upstream from the load of wood 6, the release of heat from the pyrolysis is directly consumed downstream from the load 6, or in the bottom in the case of a vertical furnace as shown in the figures. The release of heat due to the pyrolysis is strong enough to dry the rest of the wood of the load 6 and initiate the reaction, which is self-maintaining.

Figure 3 shows the initiation of the pyrolysis front 20 in the upstream part of the load 6, the heating gases G1 alone provide the supply of energy, the dilution gases G2 are formed only by still-cold gases at the downstream chamber 19. The circulation of the gases is in a minimal state, to allow the discharge of the excess of gas in the furnace module 100 in service gases G4.

A bifurcation 24 separates the dilution gases G2 into a conveying means or a bypass pipe 4 provided with closing means or a butterfly valve 132 on the one hand, service gases G4 into a conveying means or at least one pipe 16 provided with closing means or a butterfly valve 134 on the other hand.

In an alternative embodiment, the device includes, preferably downstream from this bifurcation 24, after a pipe 8, a connecting T on an extraction pipe, in particular a chimney 17, designed to discharge the gaseous oxygen that is present in the furnace, in particular that has been introduced therein in the form of air with the load of wood 6 itself. During the startup of the installation after the loading of a new load of wood 6, the closing means 134 of the pipe 16 are closed, thus prohibiting any flow of service gases G4, and the extraction pipe or the chimney 17 discharges the exiting gases G3 that are cold and that contain gaseous oxygen. Upon the appearance of first vapors leaving the chimney 17, it suffices to close the closing means 135 with which it is equipped, and to reopen the closing means 134 of the pipe 16, so as to release the passage toward the downstream direction for the service gases G4.

Figure 4 shows the system in maintained operation, the pyrolysis front 20 progresses toward the downstream direction of the load 6, the pyrolysis provides the necessary energy, the energy contribution by the heating gases G1 is minimal for just the maintenance of the temperature, the gases circulate through the bypass.

The circulation means 5 are preferably implanted in the upper part of the furnace module 100, to require these entering gases G0 to circulate from top to bottom, through the load 6, opposing the natural convection.

In the invention, at least one heating means, advantageously outside the furnace module 100, is used to produce the heating gases G1, which are used to provide the necessary energy for the initiation of the pyrolysis of the part furthest upstream from the load of wood 6. It includes a reducing furnace, so as not to generate oxygen in gaseous form O_2. This heating means can in particular uses the fourth service gases G4. In the absence of installations making it possible to use the latter, the installation 100 includes, or is connected to, an oxidizing open furnace, for their combustion and the discharge into the atmosphere of gases that do not present a risk for human health.

In one preferred embodiment, the base 3 communicates with the downstream chamber 19 or incorporates the latter, and includes the outlet pipe 8, as well as the bypass pipe 4. This base 3 can be buried or placed on the ground. It advantageously includes an outlet valve 10 for condensates, accumulated at its lowest point.

This base 3 can also make up the downstream chamber 19, or lower in the case of a basket 7 mounted vertically, from which dilution gases G2 are conveyed toward the mixing chamber 15, the rest of the exiting gases G3, made up of the service gases G4, being discharged by another conveying means toward a usage or treatment device, preferably by combustion as set out above. The system thus includes a gas circulation loop allowing precise control of the temperature in the load of wood 6.

One important advantage of the invention is to offset the problem of the prior art, related to the need, before treating a new load, to stop the furnace and wait for the load to cool, for a significant length of time.

In one preferred embodiment, the basket 7 is incorporated, at the carbonization chamber 25, into a housing 22 provided with at least one loading door. This housing 22 includes, at least at its periphery around the basket 7, at least one heat exchanger 23, the latter being designed to be tight in order to prohibit any passage of said entering gases G0 from the upstream chamber 18 toward the downstream chamber 19 in a manner other than through the load 6.

According to the invention, after the pyrolysis and complete carbonization, at the desired stage, water is sprayed on the load 6, from the upstream direction and preferably from above. The temperature in this zone is monitored, in order to ensure the vaporization of this water in contact with the load 6, but not the wetting of the latter. It is thus possible to decrease the temperature rapidly in the chamber of the furnace that contains the load 6, and to reduce the quantity of energy in this chamber.

Effective and rapid cooling of the load 6 is thus obtained by spraying water in the stream of the gas mixture G0. To that end, the furnace 100 includes cooling means, including injection means 9, in particular an injection and/or spray and/or atomization nozzle, located in the mixing chamber 15, or in the upstream chamber 18, or in both. Spraying directly in the chamber 18 makes it possible to blow water above the basket(s) 7 without creating a thermal shock on the circulation means 5, when the latter are made up of a fan.

Figure 5 shows the spraying of water; the circulation of gases is kept at its maximum. The entry of the gases G1 is closed and no longer provides energy, at G4 the last gases are discharged, next the discharge is done at 10, in particular at least at one valve, the condensates and runoff water.

The vaporization temperature of the water is quickly reached at the upper part of the load 6, the cooling is considered to be complete when the temperature at the base of this load is low enough, or usually a little above the vaporization temperature of the water, to perform the fuel removal of the basket 7. Upon opening the furnace 100, the load may catch fire in contact with the oxygen from the ambient air. The basket 7 is then placed under a quenching bell, for one or two days, in order to finalize the cooling of the charcoal, preferably in a pre-packaging transit zone.

Preferably, temperature and/or high and low pressure sensors 12 at the load, and flow rate and/or pressure and/or temperature sensors 12 of the processed gases, make up the inputs of an automated control system for carrying out the process in the installation, without an operator, for example in the form of a programmable logic controller, computer or the like, designed able to control the circulation means 5 and/or the injection means 9 and valves 10. Such a control system can also monitor one or several regulating registers 13, in particular 131 first heating gases G1 and/or 132 second dilution gases G2, and pressure and/or flow rate, and/or the regulating means 134 of the pipe 16, and 135 of the chimney 17.

The measurement of the temperature gap between the upstream and downstream directions of the load 6 allows the simple and precise monitoring of the type of carbonization, and therefore makes it possible to obtain homogeneous charcoal, depending on its degree of cooking, from the “slightly cooked” quality to the “very cooked” quality depending on the needs. This was impossible for the artisanal furnaces and very difficult in most of the industrial systems of the prior art.

The energy supplied to the heating means, in particular boiler or furnace, to produce the heating gases G1, comes from any fuel: wood, gas, pyrolysis gas or the like, or mixed.

The weight of the load before loading and after cooling allows yield monitoring of the furnace module.

The cycle time depends on the thickness of the load 6 to be passed through by the gases, and is generally shorter than the methods of the prior art, where, in particular in a tropical forest, it is known to perform only two 12-day cycles per month in a same furnace according to the prior art.

With the invention, it is possible to go very quickly to the processing of the next load, with very stabilized parameters in a boiler making up the heating means.

Preferably, the furnace module 100 is heat-insulated.

It should be noted that out of all of the energy used for carbonization, the heating means provide only a very small part thereof, and above all upon startup when it involves initiating the pyrolysis front 20 while drying wood that is wet or full of sap. The heating means must be dimensioned to allow the initiation of the pyrolysis front 20 and for temperature support, above all for the end of more endothermic carbonization. The heating means therefore behave like a priming starter. Additionally, it is thus understood the same heating means can be allocated, at the same time, to several loads whereof the state of advancement of the carbonization is different. In one particular embodiment, a same heating means can therefore supply several carbonization zones, arranged in a star, or row, or the like, near the heating means. This organization is very advantageous in the case where this heating means can be supplied by the service gases G4 coming from several carbonization zones. Furthermore, it is possible to manage several loads 6 that are at different stages of carbonization, and to offset their carbonization cycles, so as to be able to sequence the loading and unloading operations.

The design of production installations made up of furnace modules 100 each containing a load 6, distributed around the heating means, also makes the installation more easily transportable, in particular in a tropical forest where access is often not easy.

The invention also relates to such a carbonization installation, in particular for the manufacture of charcoal and/or activated charcoal, according to the method of one of claims 1 to 8, including several devices 100 according to one of claims 9 to 14. This installation includes at least one central furnace generating heating gases G1 for at least two devices 100 that are connected to it.

The net yield, after deducing the energy contributed at the heating means if the latter works with wood, between the mass of charcoal and the mass of the treated load of wood, is particularly advantageous with the invention, since it exceeds 25%, with a carbon rate close to 82%, versus the yield typically below 20% in the prior art.

In short, the heating gases G1 are those that contribute the energy to the load 6 within a furnace module, to ensure the temperature and its maintenance. They can come from a heating means outside the load 6 but integrated into the furnace module 100, or come from a heating means outside this furnace module 100 itself.

The dilution gases G2 are those that make it possible to form the gas loop, and are mixed with the heating gases G1 in the mixing chamber 15.

The entering gases G0 coming from this mixture and brought to an adequate pressure by the circulation device 5 are truly the gases driving the carbonization.

The invention provides many advantages:

- limiting overheating points;

- homogenizing the temperature of the load provided by the hot gas flows;

- limiting values of the physical properties for conducting the method, as well as characteristics of the obtained product.

In short, according to the invention, instead of burning the gases directly, only part of the loop is circulated in order to obtain a gas flow with a controlled temperature and flow rate in the load; the excellent yield of the device makes it possible to keep the majority of the gases resulting from the reaction available for another use.

The automation of the method can be complete, regarding the regulation of temperature, flow speed, pressure, flow rate.

The presence of circulation means 5 makes it possible to slow the carbonization, so as to control the parameters thereof. One is thus certain of avoiding any characteristic seizing of the furnaces of the prior art, in particular in continuous operation.

The complete device is mobile, easily transportable.

The invention is usable to manufacture activated charcoal, owing to the possibility of carbonization at a high temperature, as well as the possibility of injecting steam.

The spraying lastly has another advantage, which results from the steam generation, which acts as solvent and cleaning agent for the produced charcoal, which makes it possible to deliver a clean product suitable for better ignition, required by certain industries.

The qualifying advantages of the invention are substantial, since the non-carbonized product rate is very low, or even nonexistent, since the crossing of the gas flow homogenizes the temperatures within a given stratum of the load, unlike the usual case of a static treatment where the temperatures are very different and not very reproducible.

The invention makes it possible to preserve the large pieces, and generates few fines, unlike the usual vertical furnaces where the load drops and breaks. The reduction in handling of the load is also a factor favorable to the preservation of large pieces.

FORKULNINGSMETODE OG -ANORDNING

Krav

1. En fremgangsmåde til fremstilling af trækul og/eller aktivt kul, fra et læs brænde (6), **kendetegnet ved, at**:

- det omtalte læs (6) er anbragt i mindst én kurv (7) i en forseglet anordning mellem et primært opstrømskammer (18) og et sekundært nedstrømskammer (19),
- der genereres primære, ikke-oxiderende opvarmede gasarter (G1), der ikke omfatter ilt i form af luftformig O_2, ved hjælp af mindst ét opvarmningsmiddel uden for det omtalte læs (6),
- de omtalte primære, opvarmede gasarter (G1) føres ind i et blandingskammer (15),
- i det omtalte blandingskammer (15), blandes de omtalte primære, opvarmede gasarter (G1) med sekundære fortyndingsgasser (G2), så der dannes en blanding af ikke-oxiderende indtagsluft (G0), der ikke omfatter ilt i form af luftformig O_2,
- cirkulationsmidler (5) bruges til at sende blandingen af indtagsluft (G0) ind i det omtalte primære opstrømskammer (18) i overtryk i forhold til det sekundære kammer (19) nedstrøms fra det omtalte læs (6) for i den sidstnævnte at generere en pyrolysefront (20), som under påvirkning af de omtalte cirkulationsmidler (5) tvinges til at passere igennem det i én retning fra det omtalte primære opstrømskammer (18) hen mod det omtalte sekundære nedstrømskammer (19),
- tertiær afkastluft (G3) genindvindes i det omtalte sekundære nedstrømskammer (19) nedstrøms fra det omtalte læs (6), hvor mindst en primær del af denne føres direkte ind i blandingskammeret (15) og ved hjælp af et fremføringsmiddel (4) i form af en strøm af de omtalte sekundære fortyndingsgasser (G2), der blandes med de omtalte primære, opvarmede gasarter (G1), og hvor en sekundær del i tillæg til den primære del udledes i form af en strøm af kvartære servicegasser (G4) ved hjælp af en fremføringsmetode (8) hen mod en udløbsåbning.

2. Fremgangsmåden i henhold til krav 1, **kendetegnet ved, at** den omtalte strøm af sekundære fortyndingsgasser (G2) transporteres ved hjælp af de omtalte fremføringsmidler (4) hen mod det omtalte blandingskammer (15) adskilt fra de omtalte primære, opvarmede gasarter (G1).

3. Fremgangsmåden i henhold til et af de foregående krav, **kendetegnet ved, at** der foretages en afkøling af det omtalte læs (6) efter den afsluttede pyrolyse ved at sprøjte vand ind i den omtalte blanding af indtagsluft (G0).

4. Fremgangsmåden i henhold til et af de foregående krav, **kendetegnet ved, at** den omtalte indtagsluft (G0) reguleres i strøm og temperatur, og et gasloop styres ved at kontrollere strømmen af de omtalte opvarmede gasarter (G1) og de omtalte fortyndingsgasser (G2), hvor den omtalte kontrol af strømmene er konstrueret til at styre temperaturen på den omtalte indtagsluft (G0), og gennemstrømningshastigheden for den omtalte indtagsluft (G0) kontrolleres af cirkulationsmidler (5).

5. Fremgangsmåden i henhold til et af de foregående krav, **kendetegnet ved, at** den omtalte pyrolysefront (20) rykkes frem i det omtalte læs (6) mod den naturlige konvektion i sidstnævnte.

6. Fremgangsmåden i henhold til et af de foregående krav, **kendetegnet ved, at** de omtalte primære, ikke-oxiderende, opvarmede gasarter (G1) genereres i et forbrændingskammer, hvor der sker en ufuldstændig forbrænding, således at de omtalte primære, opvarmede gasarter (G1) er fri for luftformig ilt O_2, og hvor det omtalte forbrændingskammer er konstrueret til at levere adskillige forkulningskamre, der hver især indeholder et andet læs (6) og udsættes for en forkulningsproces uafhængig af forkulningsprocessen for de andre læs (6).

7. Fremgangsmåden i henhold til et af de foregående krav, **kendetegnet ved, at** den del af den omtalte afkastluft (G3), som ikke bruges til at danne de omtalte fortyndingsgasser (G2), styres hen mod udledningsveje og anbringelse i atmosfæren (17), særligt i form af en skorsten, og/eller hen mod fremføringsmidler, hvor den omtalte del danner servicegasser (G4) til forsyning af forbrændingsmidler som fx et ildsted, eller en brændeovn eller til forsyning af enhver anden anvendelse, enten direkte, eller gennem pakning af de omtalte servicegasser i flasker eller lignende.

8. Fremgangsmåden i henhold til et af de foregående krav, **kendetegnet ved, at** et primært opstrømskammer (18) direkte opstrøms fra det omtalte læs (6) samt et sekundært nedstrømskammer (19) direkte nedstrøms fra det omtalte læs (6) udsættes for et tryk, som er større end det atmosfæriske tryk på mellem $10{,}10^5$ and $30{,}10^5$ $P_{a.}$

9. Et ovnmodul (100) til fremstilling af trækul og/eller aktivt kul, ved at benytte fremgangsmåden i henhold til et af de foregående krav, konstrueret til i et forkulningskammer (25) at modtage en kurv (7), der er konstrueret til at modtage et læs brænde (6), og hvor det omtalte forkulningskammer (25) er anbragt mellem et opstrømskammer (18) og et nedstrømskammer (19), og det omtalte ovnmodul (100) indeholder eller er forbundet med mindst ét opvarmningsmiddel uden for det omtalte læs (6), der er konstrueret til at generere primære, ikke-oxiderende opvarmede gasarter (G1), og det omtalte ovnmodul omfatter desuden, opstrøms fra det omtalte opstrømskammer (18), som står i forbindelse med det, et blandingskammer (15) konstrueret til at modtage, på den ene side, de omtalte primære, opvarmede gasarter (G1), og, på den anden side, sekundære fortyndingsgasser (G2), er **kendetegnet ved, at** det omfatter:

- fremføringsmidler (4), der er forbundet med det omtalte nedstrømskammer (19) og det omtalte blandingskammer (15) og konstrueret til at kunne styre de omtalte sekundære fortyndingsgasser (G2), der kommer fra nedstrømskammeret (19), hen mod blandingskammeret (15), for sammen med de omtalte primære, opvarmede gasarter (G1) at danne en blanding af indtagsluft (G0),
- cirkulationsmidler (5), der konstrueret til at sende den omtalte blanding af indtagsluft (G0), i overtryk, ind i det omtalte opstrømskammer (18) i forhold til det omtalte nedstrømskammer (19),
- et fremføringsmiddel (8), der er konstrueret til at kunne lede en strøm af kvartære servicegasser (G4), der kommer fra nedstrømskammeret (19), hen mod en udløbsåbning.

10. Ovnmodulet (100) i henhold til krav 9, **kendetegnet ved, at** den omtalte kurv (7), eller en indkapsling (22) konstrueret til at modtage den omtalte kurv (7), er konstrueret til at forhindre enhver passage af den omtalte indtagsluft (G0) uden for det omtalte læs (6) bortset fra i det omtalte opstrømskammer (18).

11. Ovnmodulet (100) i henhold til et af krav 9 eller 10, **kendetegnet ved, at** det omfatter midler til at styre og regulere strømmen og temperaturen i den omtalte indtagsluft (G0) konstrueret til, på den ene side, at styre temperaturen på den omtalte indtagsluft (G0) ved hjælp af midler til at fordele gasstrømme (131) anbragt i de opvarmede gasarters (G1) bane, ved hjælp af midler til at fordele gasstrømme (132) anbragt i fortyndingsgassernes (G2) bane, ved hjælp af midler til at fordele gasstrømme (16) anbragt i en bane i en del dannet af nyttige gasser (G4) af afkastluften (G3), som stammer fra det omtalte læs (6), og den anden komplementære del af den omtalte afkastluft (G3), som danner de omtalte fortyndingsgasser (G2), og, på den anden side, ved hjælp af cirkulationsmidler (5) er konstrueret til at generere en positiv trykforskel mellem det omtalte opstrømskammer (18) og det omtalte nedstrømskammer (19) for at kunne kontrollere gennemstrømningshastigheden for den omtalte indtagsluft (G0), og de omtalte styrings- og reguleringsmidler er desuden konstrueret til at kontrollere ovnens drift, som genererer de omtalte opvarmede gasarter (G1).

12. Ovnmodulet (100) i henhold til et af krav 9 til 11, **kendetegnet ved, at** det omfatter et fundament (3), der kan modtage mindst én omtalt kurv (7), og et dæksel (1), der er konstrueret til at sidde på toppen af hver omtalt kurv (7), som kan forsegles på det omtalte fundament (3), og **ved, at** den omtalte kurv (7), eller en indkapsling konstrueret til at modtage den omtalte kurv (7), er konstrueret til at forhindre enhver passage af gas uden for det omtalte læs (6) bortset fra i det omtalte opstrømskammer (18) og i det omtalte nedstrømskammer (19), og **ved, at** det omtalte ovnmodul (100) desuden omfatter cirkulationsmidler (5), der konstrueret til at kunne sende den omtalte blanding af indtagsluft (G0), i overtryk, ind i det omtalte opstrømskammer (18) i forhold til det omtalte nedstrømskammer (19), og at det omfatter fremføringsmidler (4) fra det omtalte nedstrømskammer (19), som er konstrueret til indsamling af afkastluft (G3), der kommer fra det omtalte læs (6), til at transportere mindst en del af den omtalte afkastluft (G3), benævnt fortyndingsgasser (G2), hen mod det omtalte blandingskammer (15) adskilt fra de omtalte primære, opvarmede gasarter (G1).

13. Ovnmodulet (100) i henhold til krav 12, **kendetegnet ved, at** det omtalte fundament (3) er forbundet med det omtalte nedstrømskammer (19) eller hvori sidstnævnte indgår, og indeholder mindst én kanal (8) til udledning af servicegasser (G4), der kommer fra tertiær afkastluft (G3) modtaget i det omtalte nedstrømskammer (19) ved udløbet af det omtalte læs (6), og en omløbsledning (4) til fremføring fra den komplementære del til de omtalte servicegasser (G4) ud af den omtalte tertiære luft (G3), benævnt sekundær fortyndingsgas (G2).

14. Ovnmodulet (100) i henhold til et af krav 9 til 13, **kendetegnet ved, at** det omfatter midler til styring af forkulning og afkøling, herunder temperatur- og/eller tryksensorer (12) konstrueret til at kontrollere de omtalte cirkulationsmidler (5) og et luftspjæld (13) til regulering af de omtalte primære gasser (G1) og/eller de omtalte sekundære gasser (G2), og/eller midler til at tilføre (9) vand, der er anbragt i det omtalte opstrømskammer (18).

15. En forkulningsinstallation, særligt til fremstilling af trækul og/eller aktivt kul i henhold til metoden i et af krav 1 til 8, herunder adskillige ovnmoduler (100) hver især i henhold til et af krav 9 til 14, **kendetegnet ved, at** den indeholder mindst én hovedovn, der genererer de omtalte opvarmede gasarter (G1) til mindst to af de omtalte ovnmoduler (100), som er forbundet med den.

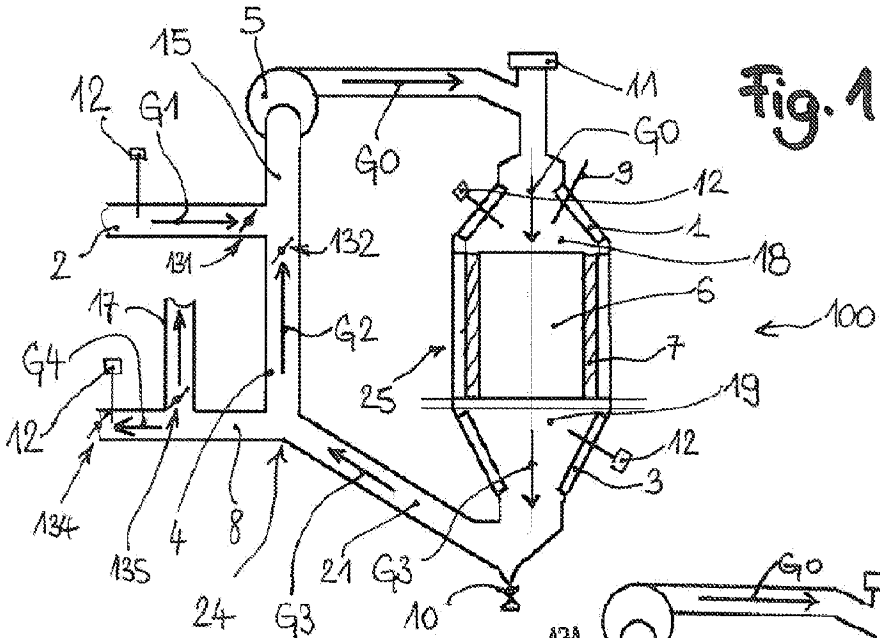

Fig. 1

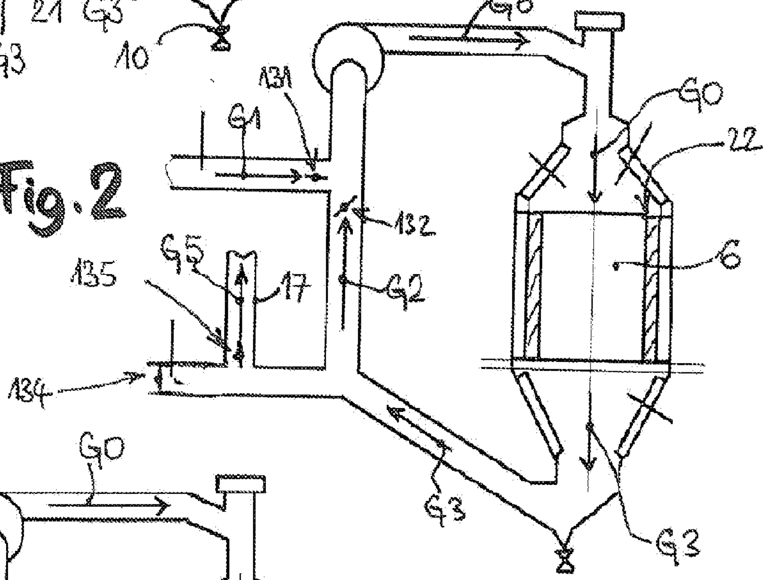

Fig. 2

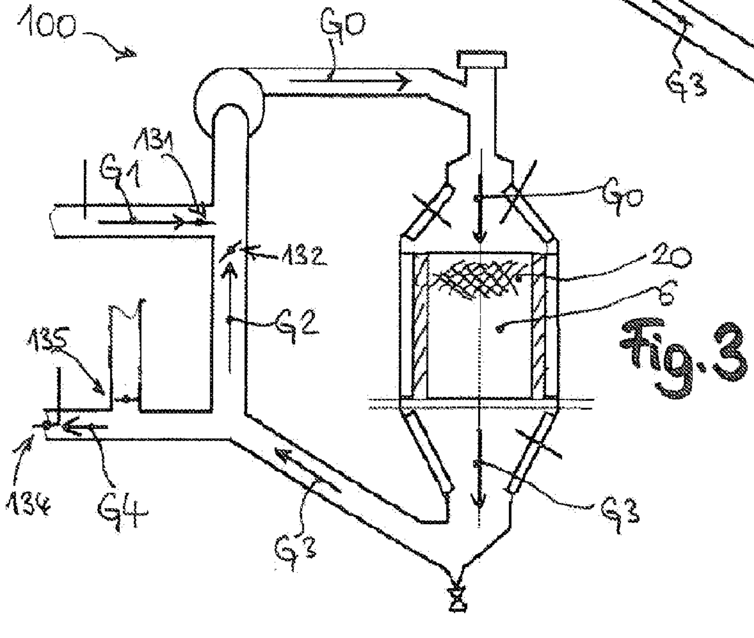

Fig. 3

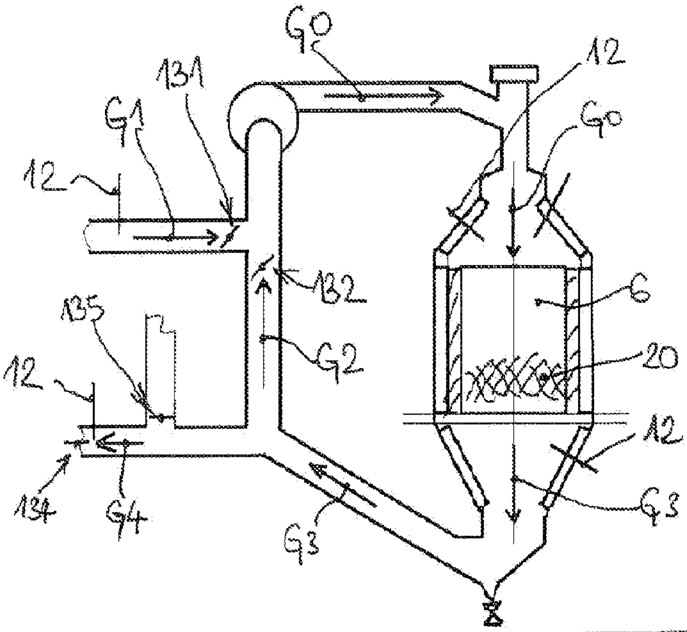
G0
131
G1
12
132
G2
135
12
134
G4
G3
12
G0
6
20
12
G3

Fig.4

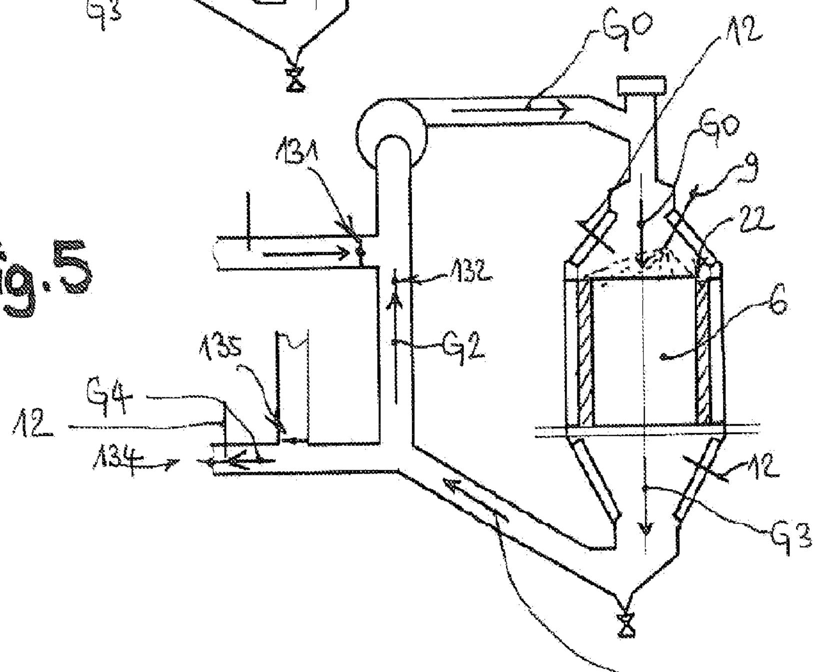
G0
12
G0
9
22
131
132
G2
6
135
G4
12
134
12
G3
G3

Fig.5