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(54) **Method and device for the combustion of granular solid fuel or liquid fuel on a granular solid carrier**

Verfahren und Vorrichtung zur Verbrennung von körnigem Festbrennstoff oder flüssigem Brennstoff auf einem körnigen festen Träger

Procédé et appareil pour la combustion de carburant solide granuleux ou de carburant liquide sur un support solide granuleux

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## Description

### Technical field of the invention

**[0001]** The present invention relates to the combustion of granular solid fuels or liquid fuels on a granular solid carrier, generally sedimentary materials which are often moist, and in particular to a method of burning such materials and a combustion device. The combustion device is, for example, particularly well suited for the combustion of oily sludge.

### Background of the invention

**[0002]** A technique generally used for the combustion of the kind of solid materials mentioned above, is combustion on a base, with feeding of the materials at the bottom by means of a screw. For certain products, this technique can cause problems with the agglomeration of ashes, as well as a poor combustion (formation of CO).

**[0003]** Fluidised beds may be used, as described in EP-0 092 622. In such a fluidised bed, the temperatures may not exceed 800°C, otherwise the ashes will agglomerate into slag and block further combustion.

**[0004]** In order to overcome this problem, cyclonic burners have been tried. A cyclone of air is created along the wall, which should carry along the injected combustibles. However, due to centrifugal forces, the combustibles will be thrown against the wall, and will simply slide down, thus shortening the time of residence of the combustibles in the combustion process and creating a blocking layer at the bottom of the cyclonic burner.

**[0005]** US-4,351,251 describes a combustion apparatus for burning pelletised organic material and/or liquid fuel. A primary air supply supplies air to the burner combustion chamber and the fuel is fed with the primary air. A swirling pattern of air in combination with the fuel feed is created. The swirling action creates an area of negative pressure located in the middle of the swirling pattern, and a flow of air under pressure is directed into this area of negative pressure. Furthermore, air entering towards the centre rear of the combustion chamber generates a second swirling pattern. The air being directed in a reverse direction to the flow of air serves to entrap heavier particles of fuel in the combustion chamber to come to a more complete combustion, while the second swirling pattern serves to avoid a dead zone at the rear end of the combustion chamber, and to avoid that heavier particles leave the combustion chamber at that rear end.

**[0006]** The combustion apparatus described above will present, when combusting solid fuel, the disadvantage that ashes will agglomerate and possibly adhere to the bottom of the combustion apparatus. In order to be able to evacuate the ashes, the combustion chamber would have to be cleaned which would almost certainly necessitate stopping the combustion. Generally, the known combustion apparatus appears to be better designed for liquid fuel.

**[0007]** A cyclonic combustion apparatus in vertical position with evacuation of particles is described in US-4,002,25. Two fluid streams enter the combustion chamber in two distinct fluid paths moving is vortex flows about the axis in the same direction of rotation, and the respective energy flow rates of fluid in these paths are comparable. The vortex flows progress axially towards one another before combining in the middle where they meet, to create a localised inward radial flow. Subsequently, the fluid leaves the radial flow and moves axially towards and out through a discharge tube. Fuel is tangentially introduced at the upper side of the combustion apparatus and moves downwards along the inside wall of the combustion chamber. Lighter parts of the fuel are moving radially where both vortex flow paths meet each other, and are then taken up by the axially upward flow. Heavy particles go down and will be evacuated from the bottom of the combustion apparatus without being totally burnt. There is no circulatory flow of the fuel in the chamber.

**[0008]** WO 92/14969 describes a vertical cyclone furnace. Primary air together with the fuel is blown in through tangential injection nozzles, thus creating a vortex. Combustion takes place in a downwardly-directed spiral movement. All particles collect at the bottom of the furnace, where they are further combusted and thus will agglomerate. A rotating cooled ash scraper is provided for removing ash from the bottom area of the furnace. The ashes thus will not stick to the wall of the furnace, but they will agglomerate to each other, and complete combustion may be impaired.

**[0009]** US 5024170 describes a vertical cyclone furnace where the combustible solid material is injected with air to generate a first vortex flow and where secondary air is injected from the top of the combustion chamber to generate a hight velocity second vortex flow within the first vortex flow.

**[0010]** It is an object of the present invention to provide a method and a device for burning granular solid fuel or liquid fuel on a granular solid carrier, whereby the residence time of the solid material in the combustion process is long enough to obtain a complete and good combustion.

**[0011]** It s a further object of the present invention to provide a method and a device for burning granular solid fuel or liquid fuel on a granular solid carrier, whereby the combustion is not blocked by agglomeration of solid materials.

### Summary of the invention

**[0012]** The above objectives are accomplished by a device and a method for the combustion of granular solid fuel or liquid fuel on a granular solid carrier according to the present invention.

**[0013]** The granular solid fuel or the liquid fuel on a granular solid carrier, hereinafter called fuel, is burnt in suspension in a vertical combustion device comprising a combustion chamber with a top and a bottom and a vertical peripheral wall disposed around a longitudinal axis. The solid materials have for example, granular dimensions between 0.1 and 6 mm in diameter. Examples of such granular solid materials are grape-stones, almond shells, waste products from forest industries, waste materials after squeezing olives. Some materials may have to be forced through pelletising mills in order to obtain the right dimensions.

**[0014]** A first opening is provided in the top of the chamber for removal of hot combustion products such as gas, fly ashes and smoke. Typically the combustion device will be cylindrical, but this is not necessarily needed. It should be symmetrical around a longitudinal axis, and any deviation from cylindrical must be within the practical confines of operability. Any shape which prevents the efficient creation of a first and a second vortex flow as explained hereinafter, would be unsatisfactory.

**[0015]** The combustion device comprises a fuel inlet device for inputting through the peripheral wall granular solid fuel or liquid fuel on a granular solid carrier. It comprises a first gas inlet device for inputting a gas to generate a first vortex flow adjacent to the peripheral wall, and a second gas inlet device for inputting a gas to form a second vortex flow within the first vortex flow. The second gas inlet device is located at or adjacent the bottom of the chamber. The second vortex flow is directed upwards towards the first opening in the top of the chamber.

**[0016]** A second opening is provided in the bottom of the chamber for continuous removal of dense particles.

**[0017]** Furthermore, a deflector is provided, which cooperates with the second vortex flow to propel the fuel upwards towards the first opening and which allows dense particles to exit continuously from the second opening.

**[0018]** Preferably the fuel inlet device is located at the upper half of the combustion chamber, and the first gas inlet device is located at the lower half of the combustion chamber.

**[0019]** By means of the creation of the first and second vortex flow, the fuel materials are separated and circulated inside the combustion chamber up to complete combustion.

Preferably the second vortex flow has a velocity which is higher than the velocity of the first vortex flow.

**[0020]** The method provided in accordance with the present invention comprises the steps of inputting fuel at the peripheral wall, inputting a primary gas at the peripheral wall to generate a first vortex flow adjacent to said peripheral wall, inputting a secondary gas at or adjacent the bottom of the chamber to form a second vortex flow within the first vortex flow, the second vortex flow being directed upwards towards the first opening and having sufficient energy to propel fuel particles towards the first opening, thus forming a fuel circulation path with the first vortex flow, and continuously preventing fuel to leave the combustion chamber, allowing dense particles to leave the combustion chamber through the second opening, and removing combustion products via the first opening.

Typically the temperatures in the combustion chamber will be between 700 and 1200 °C, preferably between 900 and 1000°C. Higher temperatures could cause the ashes to melt.

**[0021]** For burning oily sludge or polymeric resins, chalk may be added in the combustion chamber, in order to avoid the formation of dioxins.

**[0022]** Other features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

**Brief description of the drawings**

**[0023]**

Fig. 1 is a schematic vertical cross-section of a combustion device according to an embodiment of the present invention;

Fig. 2 is a schematic vertical cross-section of a further embodiment of a combustion device with double walls;

Fig. 3 represents a top view of the position of trapezoidal blades generating the second vortex flow;

Fig. 4 illustrates the circulation action in the combustion chamber; and

Fig. 5 is a schematic overview of the system with controlling devices.

**[0024]** Similar objects in the different drawings bear the same reference numerals.

**Description of the preferred embodiments**

**[0025]** The present invention will be described with reference to certain drawings and certain embodiments but the present invention is not limited thereto but only by the claims. In the text and claims reference is made to a vertically mounted combustion chamber, and words such as "top", "bottom", "side", "falling" relate to this vertical orientation of the combustion chamber.

**[0026]** Fig. 1 represents a vertically positioned, cylindrical combustion device 1. The combustion chamber 2 is formed by a vertical peripheral wall 3, a top 4 and a bottom 5. The top 4 is provided with a first opening 6 for removal of hot combustion products such as gas, smoke and fly ashes. The bottom 5 is provided with a second opening 7 for continuous removal of dense particles.

**[0027]** A first vortex flow 8, is created adjacent to the peripheral wall 3 by tangentially injecting primary gas 9.

Typically primary gas 9 is injected at a speed between 30 and 35 m/s. The flow of this first vortex flow 8 is very intense at the level of the peripheral wall 3. A deflector 28 is provided at the inside of the combustion chamber 2 at or adjacent the bottom 5. Preferably the deflector 28 is formed by a wall which is slanted in a vertical sectional view. The slope of the deflector 28 depends on the material used, but generally is between 45° and 50°. A groove 15 is provided between the bottom 5 and the deflector 28. The width of the groove 15 preferably is about 3 mm.

**[0028]** At or adjacent the bottom 5, a second vortex flow 10 is created by means of injection of secondary gas 11, typically with a velocity of about 60 or 70 m/s. The second vortex flow 10 is preferably created by means of a ring 12 of trapezoidal blades 13, which in their prolongation are tangential to a fictive central circle 14 of small diameter, as can be seen on the top view represented in Fig. 3. The flow of injected secondary gas 11 is thus more radial than tangential. The secondary gas 11 moves past the groove 15 between the bottom 5 and the deflector 28. Therefore, a vortex with high speed is created, the second vortex flow 10. The speed of the second vortex flow 10 is controlled by controlling the speed of the injected secondary gas 11. The lighter the particles to be burnt are, the lower the speed of the second vortex flow 10 and the bigger its diameter has to be.

**[0029]** The fuel inlet device for inputting granular solid fuel or liquid fuel on a granular solid carrier may be mechanical or pneumatic devices, for example a screw 17, at the upper part of the combustion chamber 2. The fuel goes down following a helical line 18 along the peripheral wall 3 of the combustion chamber 2, and then falls down and slides along the deflector 28 (represented by the line 19) towards the second opening 7 in the bottom 5, to be presented to a horizontal flow of gas creating the second vortex flow 10. Particles which fall into the almost radially injected flow of gas, are carried to the second vortex flow 10 and are then transported pneumatically and vertically upwards (represented by the line 20), but under centrifugal force fall move or fall into the first vortex flow 8 again (represented by the line 21), and come down following a helical line 33 (see Fig. 4). In this way, fuel is circulated in the combustion chamber until completely burnt. Some solid matter, when completely burnt may form light ash. These light ashes are evacuated through the first opening 6 in the top 4 of the combustion chamber 2 in the form of fly ashes following path 35. Heavy elements (such as stones for example, which may be included in the fuel, but also dense glassy or stony material formed by agglomeration of ashes) are not carried along with the first and second vortex flows 8 and 10, but are eliminated through the second opening 7 at the bottom 5 of the combustion device 1 following line 34, as explained with reference to Fig. 2. The circulation action is illustrated in Fig. 4.

**[0030]** For the combustion of humid products, the secondary gas 11 may be preheated in a device with double walls, thus allowing the ignition of the products. Fig. 2 represents a practical realisation of this embodiment.

**[0031]** The combustion device 1 comprises an internal peripheral wall 3 and an external wall 22. The combustion device 1 is divided in a pre-combustion chamber 23 and a post-combustion chamber 24. Again, the top 4 of the pre-combustion chamber 23 is provided with a first opening 6, and the bottom 5 is provided with a second opening 7. Fuel is fed in by means of a screw 17 or pneumatically.

**[0032]** Secondary gas 11 is introduced between the internal peripheral wall 3 and the external wall 22, at the upper side of the combustion device 1. The gas 11 is warmed up while travelling along the internal peripheral wall 3, and it is then introduced in the pre-combustion chamber 23 through the groove 15 between the bottom 5 and the deflector 28, thus creating an second vortex flow 10 as explained hereinabove. The temperature of the injected secondary gas 11 typically is about 400°C.

**[0033]** Primary gas 9 for creating the first vortex flow 8, is injected tangentially through different channels 25, preferably situated in the peripheral wall 3 just above the bottom 5 (at the junction between the wall 3 and the bottom 5) and in any case situated in the lower half of the peripheral wall 3. This tangentially injected primary gas 9 creates a vortex of large diameter, the first vortex flow 8, lying adjacent to the peripheral wall 3 of the combustion chamber 23 and around the second vortex flow 10. The velocity of the first vortex flow 8 is much smaller than that of the second vortex flow 10.

**[0034]** A particular aspect of the present invention is that the first vortex flow 8 stabilises the second vortex flow 10, which would otherwise broaden, slow down and loose its ability of upwardly carrying fuel.

**[0035]** An adjustment device 26 is provided for performing an adjustment of the proportion of the quantity of secondary gas 11 injected for generation of the second vortex flow 10, related to the quantity of primary gas 9 injected for generation of the first vortex flow 8. This is done in order to have the fuel circulated inside the combustion chamber 2 or pre-combustion chamber 23 up to complete combustion.

**[0036]** As described above in relation to Fig. 1, the fuel goes down following a helical line along the peripheral wall 3 of the pre-combustion chamber 23, and then falls down and slides along the bottom 5 to be presented to a horizontal flow of gas creating the second vortex flow 10. At or adjacent the bottom 5 a deflector 28 is provided which co-operates with the second vortex flow 10 to propel the fuel towards the first opening, and which allows dense particles to exit continuously from the second opening 7. The fuel is transported pneumatically and vertically upwards, but under centrifugal force moves or falls in the first vortex flow 8 again. As for the previous embodiment, the fuel is circulated. Light, completely burnt ashes are evacuated out of the pre-combustion chamber 23 and into the post-combustion chamber 24 by means of the second vortex flow 10.

**[0037]** Heavy particles are evacuated out of the combustion chamber 23 into a collecting room 27 through a second opening 7 in the bottom 5, located under the level of injection of secondary gas 11.

**[0038]** The extraction of heavy particles out of the collecting room 27 takes place by means of an extraction device, e.g. a screw 29 or an ash-pan.

**[0039]** In view of the high amount of fine dust contained in certain products to be burnt, a central tube 30 may be provided, preferably made of ceramic. It is mounted through the top 4 and extends at least partially inside the pre-combustion chamber 23. At the exit of the pre-combustion chamber 23 it creates a reverse flow of the first vortex flow 8, thus augmenting the residence time of the fine fuel particles in the combustion chamber 23. The tube 30 forms a second deflector at the top of the chamber for enhancing circulation of fuel. This tube 30 also stabilises the second vortex flow 10.

**[0040]** As for the combustion, the fuel is taken at the exit of the screw 17 by the first vortex flow 8, which is poor in oxygen, and undergoes a drying and a pyrolytic flash. This gives a liberation of gas towards the axis 31 of the combustion device 1, where it will be mixed with mounting gas.

**[0041]** The speed of combustion may controlled by introducing tertiary gas 32 in the exit throat of the pre-combustion chamber 23. In the post-combustion chamber 24, a flame, still in vortex, is obtained.

**[0042]** As represented schematically on Fig. 5, preferably the temperature inside the combustion chamber 2 is measured by means of a pyrometric stick 36, preferably provided with a thermocouple, which generates a temperature signal. The fuel inlet device can, for example, be a screw driven with variable speed by fuel inlet driving device 37. The driving speed of the fuel inlet driving device 37, and thus the speed of the fuel inlet device 17, depends on the temperature measured by the pyrometric stick 36. On the basis of this temperature signal, the fuel inlet driving device 37 derives an optimal driving speed for the fuel inlet device 17, and that way the flow of fuel introduced by the fuel inlet device 17 is affected.

**[0043]** The combustion may be controlled using a parameter relating the combustion of the fuel. For instance, control may be effected by adjusting, by means of first and second $O_2$ adjustment devices 38 and 39, the amount of $O_2$ injected into the combustion chamber 2. The efficiency of the combustion can be determined using a CO measuring device 40 for measuring the amount of CO generated. The amount of $O_2$ injected depends on the measured value of the amount of CO.

**[0044]** The minimal value for the CO concentration is obtained for values of $O_2$ of 5% of the primary and secondary gas 9 and 11 injected. For these values, the gas which leaves the combustion chamber 2 through the first opening 6 at the top 4, contains dust particles between 100 and 200 ppm, according to the degree of dust contained in the fuel. This explains the importance of the central tube 30 which keeps the dust in the combustion chamber 2. By heightening the upper part 41 (free board) of the central tube 30 the combustion will further continue in the central tube 30, which implies that less CO will be generated (as the combustion will be more complete), and that gasses leaving the combustion chamber 2 may contain dust particles less than 100 ppm.

**[0045]** Tests have been carried out for burning chloride containing products. These have been burnt with chalk added. The amounts of PCB contained in the ashes were less than 0.001 mg/kg, which makes the device according to the present invention very suitable for burning chloride containing products.

## Claims

1. A combustion device (1) for burning solid fuel or liquid fuel on a granular solid carrier, comprising:

    a combustion chamber (2) with a top (4) and a bottom (126) and a vertical peripheral wall (3) enclosing the chamber (2) , a first opening (6) being provided in the top (4) of the chamber (2) for removal of hot combustion products;

    a fuel inlet device (17) for inputting fuel through the peripheral wall (3);

    a first gas inlet device (25) for inputting a gas to generate a first vortex flow (8) adjacent to the peripheral wall (3);

    a second opening (7) in the bottom (5) of the chamber (2) for continuous removal of dense particles; **characterized in that**

    a second gas inlet device (12) is provided for inputting a gas to form a second vortex flow (10) within the first vortex flow (8), the second gas inlet device (12) being located at or adjacent the bottom (5) of the chamber (2) and the second vortex flow (10) being directed upwards towards the first opening (6) in the top (4) of the chamber (2); and

    a deflector (28) is provided, the second vortex flow (10) and the deflector (28) cooperating to propel the fuel upwards towards the first opening (6) and to allow dense particles to exit continuously from the second opening (7).

2. A combustion device according to claim 1, **characterised in that** the fuel inlet device (17) is located at the upper half of the combustion chamber (2).

3. A combustion device according to any of claims 1 or 2, **characterised in that** the first gas inlet device (25) is located at the lower half of the combustion chamber (2).

4. A combustion device according to any or the preceding claims, **characterised in that** the second gas inlet device comprises a ring (12) of trapezoidal blades (13) which in their prolongation are tangent to a fictive central circle (14) of small diameter.

5. A combustion device according to any of the preceding claims **characterised in that** the first gas inlet device is formed by channels (25) for tangentially injecting gas into the combustion chamber through the peripheral wall (3).

6. A combustion device according to any of the preceding claims, **characterised in that** it furthermore comprises an adjustment device (26) for performing an adjustment of the proportion of the quantity of secondary gas (11) injected for generation of the second vortex (10) related to the quantity of primary gas (9) injected for generation of the first vortex (8).

7. A combustion device according to any of the preceding claims, **characterised in that** it furthermore comprises a pyrometric stick (36) for generating a temperature signal, a fuel inlet driving device (37) deriving the optimal driving speed for driving the fuel inlet (17) from said temperature signal.

8. A combustion device according to any of the preceding claims, **characterised in that** it furthermore comprises a CO measuring device (40) which generates a signal reflecting the amount of CO generated, this signal being fed to first and second $O_2$ adjustment devices (38, 39) which adjust the amount of $O_2$ in the primary and secondary gas (9, 11) injected in the combustion chamber(2).

9. A combustion device according to any of the preceding claims, **characterised in that** it furthermore comprises a central tube (30) mounted through the top (4) and extending at least partially inside the combustion chamber (2).

10. A method of burning granular solid fuel or liquid fuel on a granular solid carrier in a combustion chamber (2) having a top (4) and a bottom (5) and a vertical peripheral wall (3) defining the chamber (2), there being a first opening (6) in the top (4) and a second opening (7) in the bottom (5) of the chamber (2), comprising the steps of:

    inputting fuel at the peripheral wall (3);

    inputting a primary gas (9) at the peripheral wall (3) to generate a first vortex flow (8) adjacent to the peripheral wall (3);

    inputting a secondary gas (11) at or adjacent the bottom (5) of the chamber (2) to form a second vortex flow (10) within the first vortex flow (8), the second vortex flow (10) being directed upwards towards the first opening (6) and having sufficient energy to propel fuel particles towards the first opening (6), thus forming a fuel circulation path with the first vortex flow (8); and

    allowing dense particles to leave the combustion chamber (2) through the second opening (7) and removing combustion products via the first opening (6).

**Patentansprüche**

1. Verbrennungsvorrichtung (1) zum Verbrennen von Festbrennstoff oder flüssigem Brennstoff auf einem körnigen festen Träger, bestehend aus:

    einer Verbrennungskammer (2) mit einer Oberteil (4) und einem Boden (126) und einer vertikalen Umfangswand (3), welche die Kammer (2) umschließen, wobei eine erste Öffnung (6) in der Oberteil (4) der Kammer (2) zum Entfernen von heißen Verbrennungsprodukten vorgesehen ist;
    eine Brennstoffeinlassvorrichtung (17) zum Eingeben von Brennstoff durch die Umfangswand (3);
    eine erste Gaseinlassvorrichtung (25) zum Eingeben eines Gases zur Erzeugung einer ersten Wirbelströmung (8) nahe der Umfangswand (3);
    eine zweite Öffnung (7) in dem Boden (5) der Kammer (2) zur kontinuierlichen Entfernung von dichten Teilchen;

**dadurch gekennzeichnet, dass** eine zweite Gaseinlassvorrichtung (12) zum Eingeben von Gas zur Bildung einer zweiten Wirbelströmung (10) innerhalb der ersten Wirbelströmung (8) vorgesehen ist, wobei die zweite Gaseinlassvorrichtung (12) an oder nahe dem Boden (5) der Kammer angeordnet ist, und wobei die zweite Wirbelströmung (10) nach oben in Richtung auf die erste Öffnung (6) in dem Oberteil (4) der Kammer (2) gerichtet ist; und

dass ein Deflektor (28) vorgesehen ist, wobei die zweite Wirbelströmung (10) und der Deflektor (28) zum Vorantreiben des Brennstoffs nach oben in Richtung auf die erste Öffnung (6) und zum Ermöglichen des kontinuierlichen Austritts dichter Teile aus der zweiten Öffnung (7) zusammenwirken.

2. Verbrennungsvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Kraftstoffeinlassvorrichtung (17) an der oberen Hälfte der Verbrennungskammer (2) angeordnet ist.

3. Verbrennungsvorrichtung nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** die erste Gaseinlassvorrichtung (25) an der unteren Hälfte der Verbrennungskammer (2) angeordnet ist.

4. Verbrennungsvorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die zweite Gaseinlassvorrichtung einen Ring (12) aus trapezförmigen Blättern (13) aufweist, die in ihrer Verlängerung an einem fiktiven zentralen Kreis mit einem kleinen Durchmesser anliegen.

5. Verbrennungsvorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die erste Gaseinlassvorrichtung durch Kanäle (25) zum tangentialen Einspritzen von Gas in die Verbrennungskammer durch die Umfangswand (3) gebildet ist.

6. Verbrennungsvorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** sie weiterhin eine Einstellvorrichtung (26) zur Durchführung einer Einstellung des Anteils der Menge an Sekundärgas (11), das zur Erzeugung des zweiten Wirbels (10) eingespritzt wird, bezüglich der Menge des Primärgases (9) aufweist, die zur Erzeugung des ersten Wirbels (8) eingespritzt wird.

7. Verbrennungsvorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** sie weiterhin einen pyrometrischen Stab (36) zur Erzeugung eines Temperatursignals aufweist, wobei eine Kraftstoffeinlassantriebsvorrichtung (7) die optimale Antriebsgeschwindigkeit für den Antrieb des Kraftstoffeinlasses (17) von dem Temperatursignal ableitet.

8. Verbrennungsvorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** sie weiterhin eine CO-Messvorrichtung (40) aufweist, die ein Signal erzeugt, welches die Menge an generiertem CO darstellt, wobei dieses Signal zu ersten und zweiten $O_2$-Einstellungsvorrichtungen (39, 39) geführt wird, welche die Menge an $O_2$ in dem primären und sekundären Gas (9, 11) einstellen, die in die Verbrennungskammer (2) eingespritzt werden.

9. Verbrennungsvorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** sie weiterhin ein zentrales Rohr (30) aufweist, das durch das Oberteil (4) montiert ist und sich wenigstens teilweise im Inneren der Verbrennungskammer (2) erstreckt.

10. Verfahren zur Verbrennung von körnigem Festbrennstoff oder flüssigem Brennstoff auf einem körnigen festen Träger in einer Verbrennungskammer (2), die ein Oberteil (4) und einen Boden (5) und eine vertikale Umfangswand (3) aufweist, welche die Kammer (2) bilden, wobei eine erste Öffnung (6) in dem Oberteil (4) und eine zweite Öffnung (7) in dem Boden (5) der Kammer (2) vorliegen, bestehend aus folgenden Verfahrensschritten:

   Eingeben von Brennstoff an der Umfangswand (3);
   Eingeben eines primären Gases (9) an der Umfangswand (3) zur Erzeugung einer ersten Wirbelströmung (8) nahe der Umfangswand (3);
   Eingeben eines zweiten Gases (11) am oder nahe der im Boden (5) der Kammer (2) zur Bildung einer zweiten Wirbelströmung (10) innerhalb der ersten Wirbelströmung (8), wobei die zweite Wirbelströmung (10) nach oben in Richtung auf die erste Öffnung (6) gerichtet wird und ausreichend Energie für das Vorantreiben von Brennstoffteilen in Richtung auf die erste Öffnung (6) besitzt, um auf diese Weise einen Kraftstoffzirkulationsweg mit der ersten Wirbelströmung (8) zu bilden; und
   Ermöglichen von dichten Partikeln, die Verbrennungskammer (2) durch die zweite Öffnung (7) zu verlassen und Entfernen von Verbrennungsprodukten über die erste Öffnung (6).

**Revendications**

1. Dispositif de combustion (1) pour brûler du combustible solide ou du combustible liquide, sur un support solide granulaire, le dispositif comprenant :

   une chambre de combustion (2), comportant une partie supérieure (4) et une partie de fond (126), et une paroi périphérique verticale (3) définissant la chambre (2), une première ouverture (6) étant prévue dans la partie supérieure (4) de la chambre (2) pour l'évacuation des produits chauds de combustion ;
   un dispositif d'admission de combustible (17) pour l'admission de combustible à travers la paroi périphérique (3) ;
   un premier dispositif d'admission de gaz (25) pour l'admission d'un gaz afin de créer un premier écoulement tourbillonnaire (8), adjacent à la paroi périphérique (3) ;
   une seconde ouverture (7), située dans la par-

tie de fond (5) de la chambre (2), pour une évacuation en continu de particules denses ;

**caractérisé en ce qu'**il est prévu un second dispositif d'admission de gaz (12) pour l'admission d'un gaz afin de former un second écoulement tourbillonnaire (10) à l'intérieur du premier écoulement tourbillonnaire (8), le second dispositif d'admission de gaz (12) étant disposé au niveau de ou de manière adjacente à la partie de fond (5) de la chambre (2), et le second écoulement tourbillonnaire (10) étant dirigé vers le haut en direction de la première ouverture (6) ménagée dans la partie supérieure (4) de la chambre (2) ; et

**en ce qu'**il est prévu un déflecteur (28), le second écoulement tourbillonnaire (10) et le déflecteur (28) coopérant pour propulser le combustible vers le

haut en direction de la première ouverture (6) et pour permettre à des particules denses de sortir en continu à partir de la seconde ouverture (7).

**2.** Dispositif de combustion selon la revendication 1, **caractérisé en ce que** le dispositif d'admission de combustible (17) est situé au niveau de la moitié supérieure de la chambre de combustion (2).

**3.** Dispositif de combustion selon la revendication 1 ou 2, **caractérisé en ce que** le premier dispositif d'admission de gaz (25) est situé au niveau de la moitié inférieure de la chambre de combustion (2).

**4.** Dispositif de combustion selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le second dispositif d'admission de gaz comprend une couronne (12) de pales trapézoïdales (13) qui, dans leur prolongement, sont tangentes à un cercle central fictif (14) de petit diamètre.

**5.** Dispositif de combustion selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le premier dispositif d'admission de gaz est constitué par des passages (25) pour une injection tangentielle de gaz dans la chambre de combustion, à travers la paroi périphérique (3).

**6.** Dispositif de combustion selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend en outre un dispositif de réglage (26) pour procéder à un réglage de la proportion de la quantité de gaz secondaire (11), injecté pour la création du second tourbillon (10), par rapport à la quantité de gaz primaire (9), injecté pour la création du premier tourbillon (8).

**7.** Dispositif de combustion selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend en outre une baguette pyrométrique (36) pour fournir un signal de température, un dispositif de commande d'admission de combustible (37) déduisant, dudit signal de température, la vitesse optimale de commande pour commander l'admission de combustible (17).

**8.** Dispositif de combustion selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend en outre un dispositif de mesure de CO (40), qui fournit un signal représentatif de la quantité de CO produit, ce signal étant appliqué à des premier et second dispositifs de réglage de $O_2$ (38, 39), qui règlent la quantité de $O_2$ dans les gaz primaire et secondaire (9, 11), injectés dans la chambre de combustion (2).

**9.** Dispositif de combustion selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend en outre un tube central (30), monté de manière à traverser l'extrémité supérieure (4) et s'étendant au moins partiellement à l'intérieur de la chambre de combustion (2).

**10.** Procédé de combustion de combustible solide granulaire ou de combustible liquide, sur un support solide granulaire, dans une chambre de combustion (2) comportant une partie supérieure (4) et une partie de fond (5), et une paroi périphérique verticale (3) définissant la chambre (2), une première ouverture (6) étant prévue dans la partie supérieure (4) et une seconde ouverture (7) étant prévue dans la partie de fond (5) de la chambre (2), ledit procédé comprenant les étapes de :

admission de combustible au niveau de la paroi périphérique (3) ;
admission d'un gaz primaire (9), au niveau de la paroi périphérique (3), afin de créer un premier écoulement tourbillonnaire (8), adjacent à la paroi périphérique (3) ;
admission d'un gaz secondaire (11), au niveau de la partie de fond (5) de la chambre (2) ou de manière adjacente à cette partie, afin de former un second écoulement tourbillonnaire (10) à l'intérieur du premier écoulement tourbillonnaire (8), le second écoulement tourbillonnaire (10) étant dirigé vers le haut en direction de la première ouverture (6) et ayant suffisamment d'énergie pour propulser des particules de combustible en direction de la première ouverture (6), pour ainsi former un chemin de circulation de combustible avec le premier écoulement tourbillonnaire (8) ; et
évacuation des particules denses, hors de la chambre de combustion (2) par l'intermédiaire de la seconde ouverture (7), et évacuation des produits de combustion au moyen de la première ouverture (6).

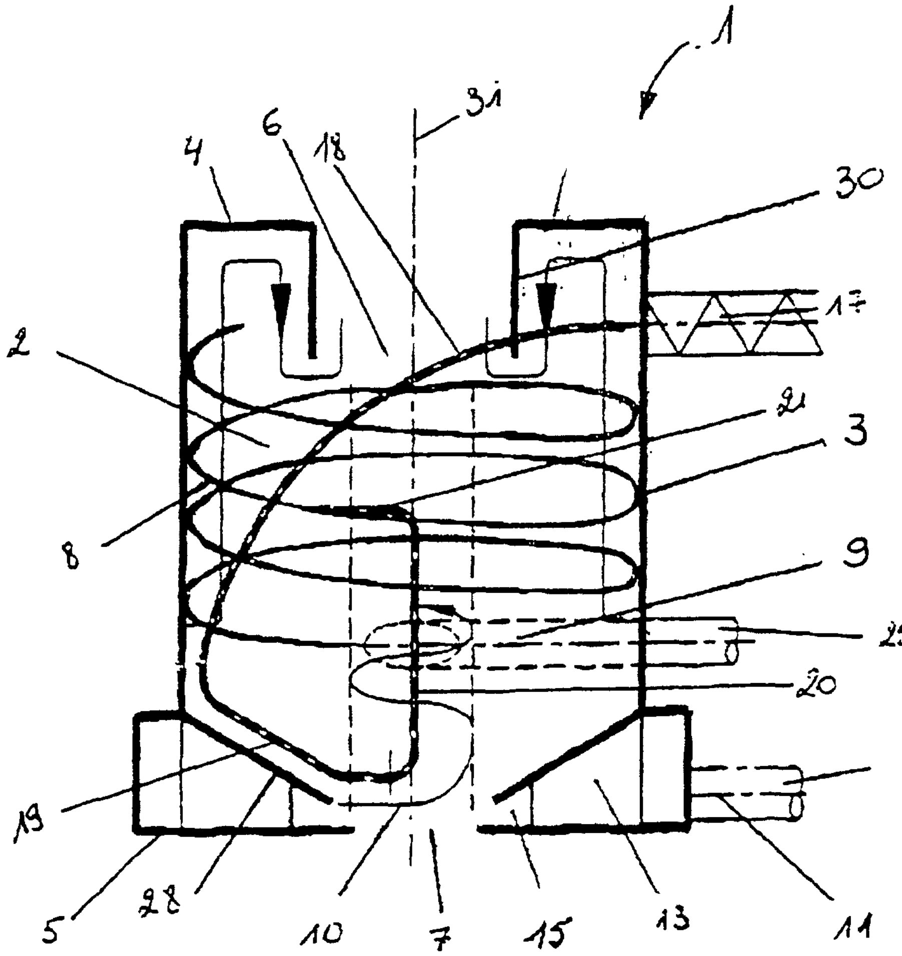


Fig 1

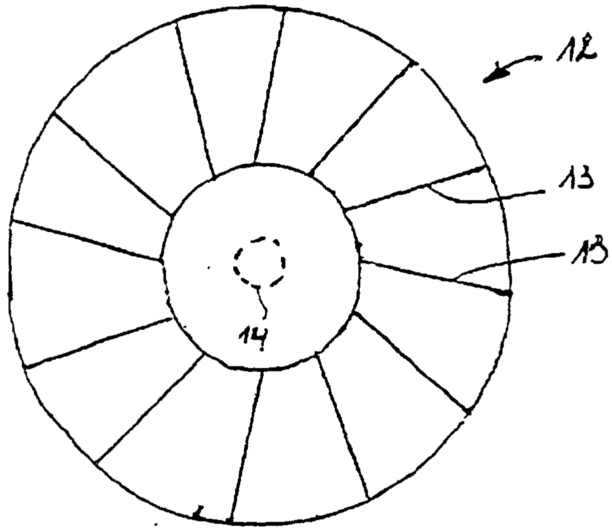


Fig.3

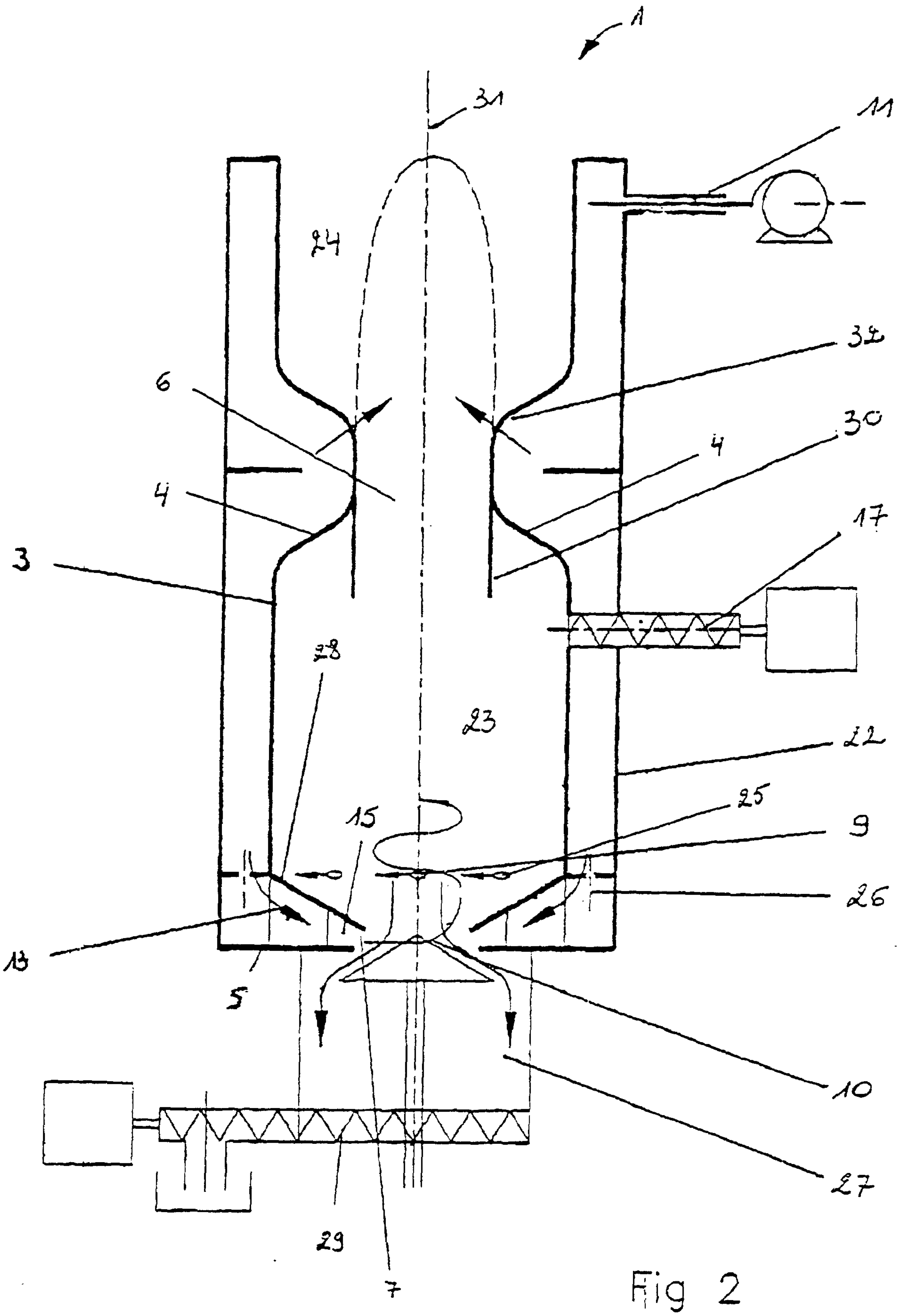


Fig 2

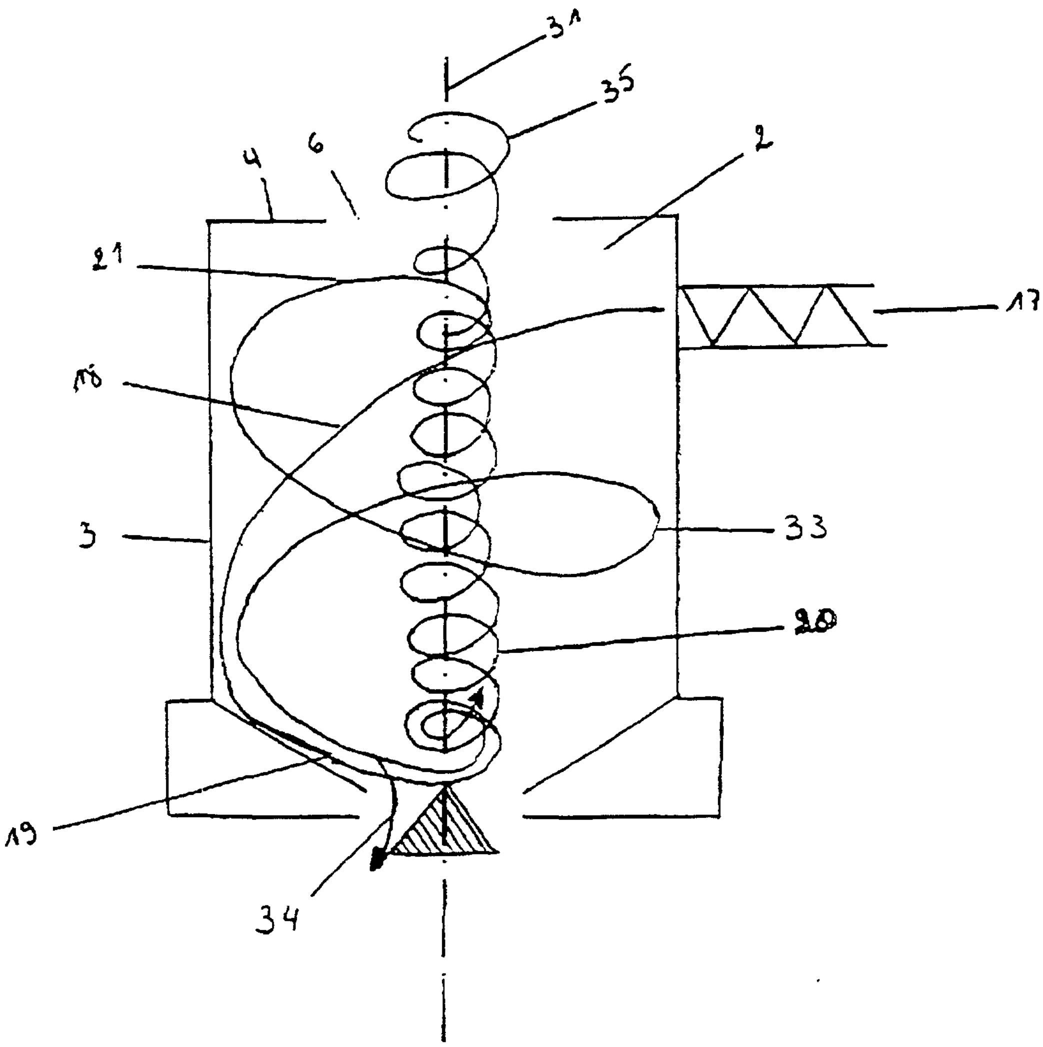


Fig. 4

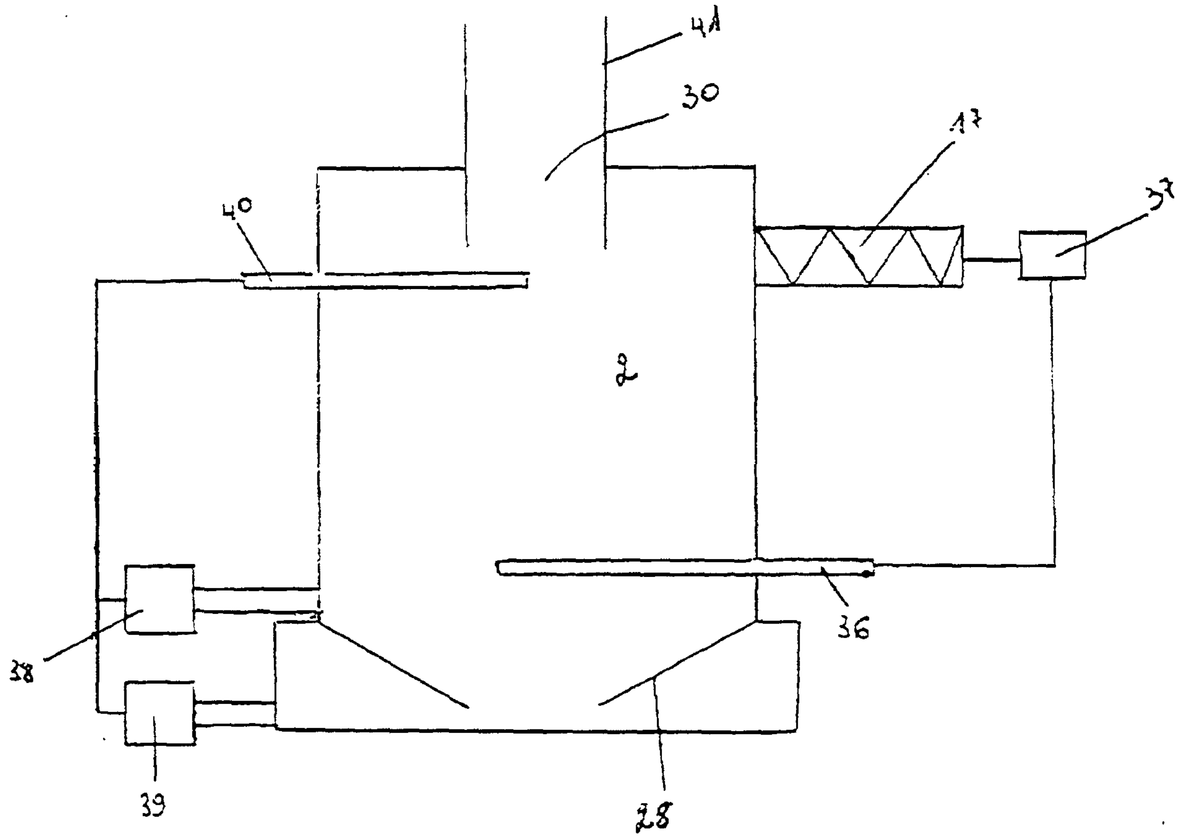


Fig. 5