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(72) Inventor: **Mustakoski, Jorma**  
**39960 Sarvela (FI)**

(74) Representative: **Eriksson, Svante Johan Christer et al**  
**Oy Jalo Ant-Wuorinen Ab**  
**Iso Roobertinkatu 4-6 A**  
**00120 Helsinki (FI)**

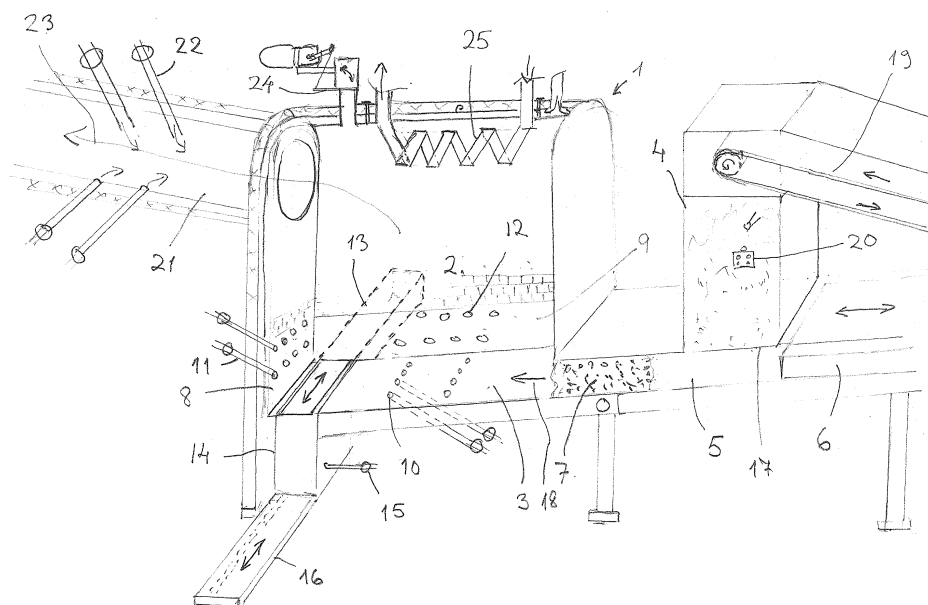
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(71) Applicant: **Mustakoski, Jorma**  
**39960 Sarvela (FI)**

(54) **Combustion facility for solid biofuels**

(57) The invention relates to a combustion facility for solid biofuels, comprising a vessel (1) having a combustion chamber (2) and a flat-surfaced stationary metal grate (3), as well as a fuel silo (4) mounted adjacent to the vessel (1) to receive biofuels, and feeding means (5,6) for feeding fuel. The invention is **characterized in that** the feeding means (5,6) comprise a water-cooled feeding shaft (5) extending from underneath the fuel silo (4) to the combustion chamber (2) in the direction of the metal grate (3) and a reciprocating feeding piston (6) mounted in this feeding shaft (5) for pushing the fuel fallen down from the fuel silo (4) to the feeding shaft (5) as a

continuous gas tight plug (7) onto the metal grate (3) of the vessel (1), that in the grate (3) as well as in the front (8) and side walls (9) of the combustion chamber (2) air nozzles (10, 11, 12) are arranged, directed to the combustion zone of the fuel, and that at the final end of the fuel lying on the grate (3) an ash removal compartment (14) covered with an upper damper (13) is arranged, said ash removal compartment being provided with additional air nozzles (15) to complete the combustion of the unburned ingredients, the bottom of which being formed by a water-cooled lower damper (16) for cooling the ash charge before being dropped down to a wagon or a container provided underneath.



## Description

**[0001]** The present invention relates to a combustion facility for solid biofuels, comprising a vessel having a combustion chamber lined with a fireproof material and a flat-surfaced stationary metal grate, as well as a fuel silo mounted adjacent to the vessel to receive bio-fuel and feeding means for feeding fuel from the fuel silo into the combustion chamber, said feeding means comprising a feeding shaft extending from underneath the fuel silo to the combustion chamber in the direction of the metal grate and a reciprocating feeding piston mounted in this feeding shaft for pushing the fuel fallen down from the fuel silo to the feeding shaft as a continuous plug onto the metal grate of the vessel, said grate being provided with air nozzles directed to the combustion zone of the fuel, and that an ash removal compartment is arranged at the end opposite to the feeding shaft of the grate.

**[0002]** The aim of the present invention is to provide a combustion facility enabling such a combustion process which is adjustable as easily and exactly as the combustion process of an oil burner, and which is capable of combusting a solid fuel completely as well as enables discharging the ash without interrupting the combustion process.

**[0003]** This aim is achieved by a combustion facility according to the invention which is characterized in that the walls of the vessel, the feeding shaft and the metal grate, onto which the fuel is fed as a gas tight plug, are water-cooled, that in addition to the air nozzles provided in the grate, air nozzles are also arranged at different levels and in different positions in the front and side walls of the combustion chamber, being directed to the combustion zone of the fuel, that all air nozzles of the combustion facility are exactly adjustable, and that the ash removal compartment is covered by an upper damper and arranged to receive one ash charge at a time, whereby additional air nozzles are led to the ash removal compartment to complete the combustion of the unburned ingredients still remaining in the ash charge, whereby the bottom of the ash removal compartment is formed by a water-cooled lower damper for cooling the ash charge before it will be dropped onto a wagon or a container provided underneath. Due to this, the combustion facility of this kind is in its combustion principle completely closed, i.e. all side and leakage airs are eliminated. Due to this, the combustion process is adjustable with high accuracy, preferably so that the combustion process is based on impulses given by an oxygen sensor developed by ABB. The adjustment may be based for instance on the residue oxygen content in the combustion gas flow. When the air nozzles are closed, the combustion process ceases, while opening the air nozzles will start up the combustion process. Due to the ash removal compartment it is possible to remove ash without interrupting the combustion process. Because the ash charges dropped down from the ash removal compartment are completely dry and already cooled, there is no need to cool the ash

with water. Consequently, there is no need to feed water used for cooling to the sewer system or the like, but the ash dropped down from the ash removal compartment is safe and can easily be treated further.

**[0004]** The feeding shaft and the feeding piston have a width corresponding to that of the grate, their cross-section being rectangular. The feeding piston is arranged to move so that, in its starting position in which it is pulled back, it is situated as a whole in that part of the feeding shaft which is located behind the bottom opening of the fuel silo, and moves during its pushing movement to a zone in the front of the discharging end of the feeding shaft to maintain a tightly pressed fuel plug preferably of a length of approx. 80 cm in the feeding shaft, whereby the fuel plug forms an effective closure against an uncontrolled flow of air into the combustion chamber and prevents effectively rear combustion.

**[0005]** Each air nozzle of the combustion facility is provided with an adjustable damper. The air nozzles arranged in the grate are directed in the moving direction of the fuel to prevent their clogging. These air nozzles are of importance, because air jets conducted through them with a high pressure effect spreading of a layer of the fuel of a thickness of approx. 50 to 200 mm on the grate and on the ash ingredients lying thereon, preventing simultaneously too intensive cooling of the fuel. Due to the effectiveness of spreading, the combustion in the fuel lying on the grate takes place as forced combustion.

**[0006]** At the upper end of the fuel silo, a feed conveyor is arranged by means of which new fuel is fed into the fuel silo to maintain a sufficient fuel level in the fuel silo. For this purpose a sensor detecting the fuel level is provided in the fuel silo, said sensor being arranged to give control signals to the drive of the feed conveyor.

**[0007]** The combustion facility is preferably provided with an oxygen sensor by means of which the combustion process is adjustable. According to a preferable embodiment said control is based on the residual oxygen content of the combustion gas flow.

**[0008]** After an ash charge dropped down to the ash removal compartment is cooled, the lower damper is arranged to open for a while to allow the ash charge to fall down to a wagon or a container positioned below said compartment. After the lower damper is closed, the upper damper is arranged to open for a while to receive a new charge of hot ash in the ash removal compartment.

**[0009]** The upper damper of the ash removal compartment is open to such an extent at its sides sufficient to allow the combustion gases generated in the ash removal compartment as well as the additional air fed thereto to flow upwards through the combustion chamber to a heat recovery device simultaneously contributing to the combustion taking place on the grate.

**[0010]** Preferably, after the combustion chamber, a water-cooled afterburner is arranged, having provided with additional air nozzles directed against the combustion gas flow to effect good mixing of the combustion gases. The use of this additional air ensures complete

combustion in the postcombustion. The combustion process is controlled continuously, preferably by means of an oxygen sensor, which is arranged to measure the residual oxygen content of the combustion gas flown through the afterburner.

**[0011]** At the upper end of the combustion chamber a flushing damper is provided which is arranged to open automatically, for example, in the situations of an electric breakdown allowing in such situations the unburned combustion gases to exhaust from the combustion chamber. Simultaneously it serves as an explosion damper.

**[0012]** According to a preferable embodiment, a spiral of a fireproof material is mounted at the upper end of the combustion chamber, through which spiral air to be heated can be led, whereby the air is heated to a temperature of 700 to 1000 °C. The obtained very hot air can be conducted, for instance, to a turbine, where water is sprayed into said air so that vapour-air flows into the combustion chamber of the turbine causing the same effect as kerosine in the turbine of an air plane. The turbine may, in turn, rotate a generator to generate electricity. The spiral may also be used as a heater of the combustion air to facilitate the combustion process, especially when moist fuels are combusted.

**[0013]** In the following the invention is described in more detail referring to a drawing showing an example of a combustion facility according to the invention as a perspective schematic and partly sectional view.

**[0014]** The combustion facility for solid biofuels shown in the drawing comprises a water-cooled vessel 1, having a combustion chamber 2 lined with a fireproof material and a flat-surfaced stationary metal grate 3 which also is water-cooled. Adjacent to the vessel 1, a fuel silo 4 is mounted to receive biofuel, whereby a water-cooled feeding shaft 5 extending from underneath the fuel silo 4 to the combustion chamber 2 in the direction of the metallic grate 3 is arranged for feeding fuel from the fuel silo 4 into the combustion chamber 2, and in this feeding shaft a reciprocating feeding piston 6 is arranged to push the fuel dropped down from the fuel silo 4 to the feeding shaft 5 as a continuous gas tight plug 7 onto the metal grate 3 of the vessel. Exactly adjustable air nozzles 10, 11, 12 are arranged in the metal grate 3 and at different levels and in different positions in the front 8 and side walls 9 of the combustion chamber 2, said air nozzles being directed to the combustion zone of the fuel lying on the grate 3. At the end of the grate 3, opposite to the feeding shaft 5, an ash removal compartment 14 covered with an upper damper 13 and intended to receive one ash charge at a time is arranged, to which ash removal compartment additional air nozzles 15 are conducted in order to complete the combustion of the unburned ingredients still remaining in the ash charge. The bottom of the ash removal compartment 14 is formed by a water-cooled lower damper 16 for cooling the ash charge before being dropped into a wagon or a container positioned underneath said compartment. Thus the ash removal compartment also recovers the heat from the ash which

normally is fiery red. The lower damper 16 is arranged to open for a time when the ash lying thereon has been cooled, and immediately after the closure of the lower damper 16, the upper damper 13 is arranged to open for a time sufficiently to receive a new charge of hot ash in the ash removal compartment 14.

**[0015]** The upper damper 13 of the ash removal compartment 14 is open to such an extent at its sides sufficient to allow the generated combustion gases and additional air fed thereto to flow upwards through the combustion chamber to a heat recovery device, which simultaneously contributes to the combustion process taking place on the grate 3.

**[0016]** The feeding shaft 5 and the feeding piston 6 have a width corresponding to that of the grate 3, their cross-section being rectangular. The feeding piston 6 is arranged to move so that in the position in which it is pulled back to its starting position, it is situated as a whole in that part of the feeding shaft 5 which is located behind the bottom opening 17 of the fuel silo 4, and moves during its pushing movement to the zone in the front of the discharging end of the feeding shaft 5 to maintain preferably a tightly pressed fuel plug of a length of approx. 80 cm in the feeding shaft 5. Said plug prevents effectively air from entering the combustion chamber 2 through the feeding shaft 5, preventing simultaneously effectively rear combustion. The plug 7 allows complete control of the combustion with different fuels enabling so that the combustion facility can operate in the same manner as oil burner systems, i.e. that heat is generated only when heat is needed.

**[0017]** Air nozzles 10 arranged in the grate 3 are directed in the moving direction of the fuel which effectively prevents their clogging. The air jets fed through these air nozzles 10 with high pressure are very important, because they effect spreading of a layer of fuel lying on the grate 3, the layer having generally a thickness of approx. 50 to 200 mm, effecting thus forced combustion of the fuel. As stated above, the front 11 and side air nozzles 12 are positioned in the front walls 8 and side walls 9 of the combustion chamber 2 at different levels and in different positions and are directed towards the combustion zone of the fuel proceeding forward on the grate effecting a concentrated, intensive local combustion process.

**[0018]** The combustion facility further comprises a feeding conveyor 19 ending at the upper end of the fuel silo 4, said conveyor being arranged to feed new fuel into the fuel silo 4, a sensor 20 measuring the fuel level in the fuel silo according to control signals given by said sensor to maintain the fuel level within the predetermined range.

**[0019]** A water-cooled afterburner 21 provided with additional air nozzles 22 enabling intensive mixing of the fuel flow 23 is preferably arranged after the combustion chamber 2 ensuring complete combustion in the post-combustion. The combustion process is preferably controlled by an oxygen sensor. Said control is based on the residual oxygen content of the combustion gas 23 flown through the afterburner 21.

[0020] At the upper end of the vessel 1 a flushing damper is arranged which opens automatically in situations of electrical breakdown, serving simultaneously as an explosion damper.

[0021] At the upper end of the combustion chamber 2, a spiral 25 of fireproof material is mounted, through which air to be heated can be led. Said air to be heated is intended to be blown to the spiral where it is heated to a temperature of 700 to 1000 °C. In a preferable embodiment the obtained very hot air is conducted to a turbine, wherein water is sprayed to it, so that vapour-air flows to the combustion chamber of the turbine causing the same effect as kerosine in the turbine of an air plane. The turbine may, in turn, rotate a generator to generate electricity. Said spiral 25, together with its connection tubes, is preferably constructed so that it can easily be removed, for example by installing said spiral 25 in a removable hatch. According to another alternative said spiral, when it is not employed for generating electricity, is used as a heater of the combustion air which is advantageous for the combustion process, especially when moist fuels are combusted.

[0022] The combustion facility works as environmentally acceptable as possible causing a minimum of air pollution, because the combustion process is during the whole process completely controlled. The ash removal compartment contributes to an ecologically and from the view of environment protection acceptable operation of the combustion facility.

[0023] Due to the construction according to the invention in the combustion facility no sand bed nor devices to maintain such a sand bed are needed. The combustion takes place on the plane metal grate on its own ash. The production of heat may be started and finished according to heat requirement in the same manner as in oil or gas burner systems. Due to this, it is not necessary to arrange any separate buffer heat boiler for storing uncontrolled heat, nor technology required thereto. Due to the completely closed combustion process, the combustion may be stopped within a few ten seconds after feeding of oxygen, i.e. air, has been stopped. The combustion process may be restarted within a few ten seconds by resetting feeding of oxygen. The fuel present in the combustion chamber will catch fire immediately after new oxygen is fed into the combustion chamber, suitably automatically controlled by an oxygen adjuster.

## Claims

1. A combustion facility for solid biofuels, comprising a vessel (1) having a combustion chamber (2) lined with a fireproof material and a flat-surfaced stationary metal grate (3), as well as a fuel silo (4) mounted adjacent to the vessel (1) to receive biofuels, and feeding means (5,6) for feeding fuel from the fuel silo into (4) the combustion chamber (2), said feeding means comprising a feeding shaft (5) extending from

underneath the fuel silo (4) to the combustion chamber (2) in the direction of the metal grate (3) and a reciprocating feeding piston (6) mounted in this feeding shaft (5) for pushing the fuel fallen down from the fuel silo (4) to the feeding shaft (5) as a continuous plug (7) onto the metal grate (3) of the vessel (1), said grate being provided with air nozzles (10) directed to the combustion zone of the fuel, and that an ash removal compartment (14) is arranged at the end opposite to the feeding shaft (5) of the grate (3), **characterized in that** the walls of the vessel (1), the feeding shaft (5) and the metal grate (3) onto which the fuel is fed as a gas tight plug (7) are water-cooled, that in addition to the air nozzles (10) provided in the grate (3) air nozzles (11,12) are also arranged at different levels and in different positions in the front (8) and side walls (9) of the combustion chamber (2), said air nozzles (11,12) being directed to the combustion zone of the fuel, that all air nozzles (10,11,12) of the combustion facility are exactly adjustable, and that the ash removal compartment (14) is covered by an upper damper (13) and arranged to receive one ash charge at a time, whereby additional air nozzles (15) are led to the ash removal compartment to complete the combustion of the unburned ingredients still remaining in the ash charge, the bottom of the ash removal compartment being formed by a water-cooled lower damper (16) for cooling the ash charge before it will be dropped to a wagon or a container provided underneath.

2. The combustion facility according to claim 1, **characterized in that** the feeding shaft (5) and the feeding piston (6) have a width corresponding to that of the grate (3), their cross-section being rectangular, and that the feeding piston (3) is arranged to move so that, in its starting position in which it is pulled back, it is situated as the whole **in that** part of the feeding (5) shaft which is located behind the bottom opening (17) of the fuel silo (4) and moves during its pushing movement to a zone in the front of the discharging end of the feeding shaft (5) to maintain a tightly pressed fuel plug of preferably a length of approx. 80 cm in the feeding shaft (5).
3. The combustion facility according to claim 1, **characterized in that** the air nozzles (10) arranged in the grate (3) are directed in the moving direction (18) of the fuel.
4. The combustion facility according to claim 1, **characterized in that** a feeding conveyor (19) is arranged to feed new fuel to the upper end of the fuel silo (4) according to control signals given by a sensor (10) detecting the fuel level in the fuel silo.
5. The combustion facility according to claim 1, **characterized in that** after the combustion chamber (2)

a water-cooled afterburner (21) is arranged, being provided with additional air nozzles (22) directed against the fuel flow (23).

6. The combustion facility according to claim 5, **characterized in that** an oxygen sensor is arranged to adjust the combustion process, preferably on the basis of the residual oxygen content of the combustion gas flown through the after burner (21). 5
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7. The combustion facility according to claim 1, **characterized in that** the lower damper (16) of the ash removal compartment (14) is arranged to open for a while when the ash charge lying thereon has been cooled, and immediately after the lower damper (16) has been closed, the upper damper (13) is arranged to open for a while to receive a new hot ash charge in the ash removal compartment (14). 15
8. The combustion facility according to claim 7, **characterized in that** the upper damper (13) of the ash removal compartment (14) is open at its sides to such an extent sufficient to allow the combustion gases generated in the ash removal compartment (14) as well as additional air fed thereto to flow upwards through the combustion chamber (2) to a heat recovery device, simultaneously contributing to the combustion taking place on the grate (3). 20 25
9. The combustion facility according to claim 1, **characterized in that** at the upper end of the vessel (1) a flushing damper is provided which is arranged to open automatically in situations of an electrical breakdown. 30
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10. The combustion facility according to claim 1, **characterized in that** at the upper end of the combustion chamber (2) a spiral (25) of a fireproof material is arranged through which air to be heated can be conducted. 40
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