

Method and device for controlling injection of primary and secondary air in an incineration system.

Field of the invention

5 The invention relates to a device for incinerating waste comprising rows of secondary air nozzles divided into segments. The invention relates to a method for controlling several parameters of secondary air injection including at least one of the parameters: flow, speed, turbulence, volume, composition and temperature, for optimizing the incinerating process in an incineration system. The invention relates to a method for controlling primary air injection.

10 The invention also relates to an incineration equipment, functioning in accordance with said methods enabling the control of primary and secondary air injection.

Background of the invention

15 The combustion process of waste is a rather complex one because homogeneous and heterogeneous reactions take place, not only on the incineration grate, but also above the grate. The furnace-boiler part comprising a combustion chamber and a post-combustion chamber is a critical part of an incineration installation and needs to be designed with great care. The most important properties for this type of furnace-boiler are good performance, high flexibility, good availability and reliability with an acceptable lifetime of the different pressure

20 parts. Flexibility is of utmost importance, due to the variability of the waste characterized by e.g. its composition and calorific value. The furnace-boiler must be able to perform under these permanent changing conditions and produce steam or heat, in an as stable as possible way.

25 Since the implementation of the EU Waste Incineration directive (2000/076), requiring a residence time of at least two seconds at temperatures above 850°C for municipal waste, combined with the intensive use of selective residual waste and high calorific "problematic" and heterogeneous waste fuels, conditions for achieving a complete combustion have become more demanding today. A large number of existing installations are not designed to operate under these conditions and needed primary modifications of the combustion system

30 in order to comply with these new requirements.

 To comply with these new requirements several new technologies have been developed and implemented during recent years. In order to increase the efficiency of the combustion and reduce the discharge of pollutants into the atmosphere, secondary air

providing additional oxygen for the combustion process is delivered to the furnace-boiler to improve burning of the combustible waste gases. For example, DE4401821 describes a method and device for improving the combustion consisting of a displacement body with a secondary air supply system. With this new secondary air injection system the combustion and post-combustion process can be strongly improved and can result in a much shorter and clearly defined burnout of the flue gases.

As used herein, the terms displacement body, bluff body and prism body are used interchangeably. However, one of the main problems of obtaining an efficient combustion is the good mixing of the secondary air. The introduction of secondary air is difficult to fine-tune. Moreover, due to the absence of enough turbulence induced by injection of the secondary air in the furnace-boiler, adequate mixing of the secondary air with the combustible waste gases is not achieved, resulting in an incomplete combustion. In addition, the introduced secondary air is often not properly conditioned to take immediately part in the post-combustion process when injected in the furnace-boiler. Consequently, it will take a longer time for the post-combustion process to reach a complete burnout of the flue gases, and injection of non-conditioned secondary air in the furnace-boiler may even slow down the post-combustion process.

Another problem is that the temperature throughout a cross-section of the post-combustion chamber is not constant; pockets of flue gases are sometimes hotter or cooler than the optimum temperature causing undesirable side effects such as corrosion, slagging and fouling.

In order to solve above-mentioned problems, the present invention provides a new device comprising an improvement on the primary air and secondary air injection systems, a method for controlling several parameters of the secondary air, including flow, speed, turbulence, volume, composition and temperature, and a method for controlling primary air injection. Using this device and method leads to a highly efficient combustion process characterized by generating low initial emissions and able to cope with the EU-directive regulations.

Summary of the invention

One embodiment of the present invention is a device for incineration of solid materials
5 comprising:

- a feeding system able to introduce the solid materials in a furnace,
- a grate system comprising several grate elements,
- a furnace able to incinerate said solid materials,
- a post-combustion chamber able to burn out the produced flue gases resulting from
10 said incineration,
- a primary air supply system capable of differentially distributing air across different grate elements and across the width of the grate,
- a displacement body placed at the combustion chamber exit and entrance of the post-combustion chamber able to split the produced flue gas flow in two separate flue gas
15 streams,
- a bend in such shape of the device inner front and rear walls, that together with the outline of the displacement body creates two venturi-shaped flue gas passages at the inlet of the post-combustion chamber,
- two pairs of rows of secondary air injection nozzles located immediately at the
20 combustion chamber exit and entrance of the post-combustion chamber, one pair located on furnace inner front wall and the opposing displacement body wall; another pair located on the furnace inner rear wall and the opposing displacement body wall,

characterised in that each row of secondary air injection nozzles is divided into two or
25 more segments, each segment comprising two or more nozzles, such that the flow of air through any one segment is capable of being different from that of directly adjacent segments.

Another embodiment of the present invention is a device as described above wherein
30 each segment and segment opposite thereto form pairs of segments on opposite pairs of rows of secondary air nozzles.

Another embodiment of the present invention is a device as described above wherein the air flow to each segment is controlled by one or more valves and/or by modulating one or more air fans and/or according to the selected diameters of the secondary air injection nozzles within said segment.

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Another embodiment of the present invention is a device as described above wherein

- each segment, and segment located opposite thereto contains a larger and smaller diameter of said nozzles,
- nozzles having the larger diameter are adjacent to the nozzles having a smaller diameter

within said segments

- the nozzles are aligned in opposing segments such that those of the larger diameter are placed directly opposite nozzles having the smaller diameter.

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Another embodiment of the present invention is a device as described above further comprising any array of four or more temperature sensors, each sensor located above an area defined by a pair of segments.

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Another embodiment of the present invention is a device as described above whereby the secondary air is provided via secondary air supply ducts ending in injection nozzles, passing through the front- and rear- wall of said device as well as through the membrane-wall of the displacement body.

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Another embodiment of the present invention is a device as described above whereby, the secondary air supply duct consists of two or more concentric ducts, inside of the displacement body or along the exterior of the furnace-boiler walls.

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Another embodiment of the present invention is a device as described above whereby the inner front and rear walls of said device are bent in such shape that, together with the outline of the displacement body, two venturi-shaped flue gas passages with an opening angle (α / β) between 20° and 40° are created in order to increase the flue gas turbulence in the venturi-shaped mixing zone.

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Another embodiment of the present invention is a device as described above wherein the displacement body is made in the shape of a distorted rhomboidal prism.

Another embodiment of the present invention is a method for incinerating solid materials comprising the use of a device as described above.

Another embodiment of the present invention is a method as described above further comprising the steps of

- a) monitoring the oxygen content of the flue gases,
- 10 b) determining from step a) the total air flow required by said device,
- c) distributing air to the primary and secondary air supply systems such that the total air flow is maintained according to step b),
- d) monitoring the temperature of each temperature sensor,
- e) averaging the temperature of the temperature sensors located in each flue gas stream,
- 15 f) comparing the averaged temperatures of step e) to determine the hotter of the two gas streams,
- g) increasing the flow of secondary air through the secondary air nozzles located below the hotter of the two gas streams, and decreasing the flow of secondary air in the nozzles located below of the cooler of the two gas streams, so maintaining overall the same total of air flow in
- 20 the secondary air system, and
- h) not changing the flow of secondary air if both gas streams have the same temperature according to step f), so maintaining overall the same total of air flow in the secondary air system.

Another embodiment of the present invention is a method as described above further comprising the steps of:

- i) decreasing the flow of primary air beneath the grate elements proximal to the feeder system, when the hotter of two gas streams determined in step f) is located proximal to the feeder system, and increasing the flow of primary air in the area beneath the remainder of
- 30 the grate elements, so maintaining the same total of air flow in the primary air system,
- j) increasing the flow of primary air beneath the grate elements proximal to the feeder system, when the hotter of two gas streams determined in step f) is located proximal to the output

system, and decreasing the flow of primary air in the area beneath the remainder of the grate elements, so maintaining the same total of air flow in the primary air system,
k) not changing the flow of primary air if both gas streams have the same temperature according to step f), so maintaining the same total of air flow in the primary air system.

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Another embodiment of the present invention is a method as described above further comprising the steps of:

l) comparing the temperature of each temperature sensor monitored in step d) with the average determined in step e),

10 m) increasing the flow of secondary air in both segments with secondary air nozzles located beneath the sensor detecting a temperature hotter than the average determined in step e), and decreasing the flow of secondary air to the other segments, so maintaining the same total of air flow in the secondary air system,

15 n) decreasing the flow of secondary air in both segments with secondary air nozzles located beneath the sensor detecting a temperature lower than the average determined in step e), and increasing the flow of secondary air to the other segments, so maintaining the same total of air flow in the secondary air system,

20 o) not changing the flow of secondary air if the temperatures detected by the sensors are the same as the average determined in step e), so maintaining the same total of air flow in the secondary air system.

Another aspect of the invention relates to a method for the thermal treatment of solid materials in an incinerator comprising a combustion chamber and a post-combustion chamber, said method essentially consisting of:

- 25 - feeding the solid materials into the combustion chamber,
- stage combusting of said introduced materials thereby producing flue gases which are directed to said post-combustion chamber,
- dividing said flue gases into two separated flue gas streams by means of a displacement body present at the entrance of the post-combustion chamber
30 defining two venturi-shaped flue gas passages;

characterized by injecting secondary air immediately at the combustion chamber exit and at the entrance of the post-combustion chamber and by controlling said secondary air injection

by at least one of the following parameters: flow, turbulence, volume, composition, speed or temperature.

Present invention provides a method for controlling several parameters of the primary
5 air and secondary air injection and a device able to perform said method, which will greatly improve the efficiency of the combustion process, which will reduce emissions and will comply with the more severe combustion requirements.

Detailed description of the invention

10 Several examples of possible execution according to the present invention are illustrated in the following Figures.

Fig. 1a shows a cross-sectional view of an incineration furnace-boiler or incineration device provided with a displacement body or prism [5] according to the invention.

15 Fig. 1b represents a partial cross-sectional view of nozzles [30], [31] for the injection of secondary air in the device shown in Figure 1a.

Fig. 2a represents a detailed perspective view of an oscillating flap [20] of Figure 1b.

Fig. 2b to 2d represents schematically three positions in a top view of the flap [20] of Figure 2a.

20 Fig. 3a is a schematic perspective view of a nozzle [30], [31] provided with a rotating valve [20].

Fig. 3b is a schematic cross-sectional view of a series of nozzles [30], [31] whereby each nozzle [30], [31] is provided with a separate rotating valve [20].

Fig. 3c is a schematic cross-sectional view of a series of nozzle [30], [31] whereby the secondary air supply channel [12], [13], [14] is provided with a rotating valve [20].

25 Fig. 4 shows a fragment of an incinerating system according to above description, and angles formed by the inner walls of the post combustion chamber.

Fig. 5 shows a cross-sectional view of two arrays of nozzles both in-line, with alternate and opposite nozzles [42], [43] having a different cross-sectional diameter.

30 Fig. 6 shows a cross-sectional view of a displacement body [5] provided with concentric tubes [47], [48], [49] being supply ducts for guiding the secondary air to the different zones over the width of the incineration system.

Fig. 7 shows a three dimensional view of a furnace-boiler comprising an example of one pair of nozzle rows [71] and [72] which have been divided into three sections [73], [74] and [75] in accordance with the invention.

Fig. 8 shows a three dimensional view of a furnace-boiler comprising an example of an array of temperature sensors [SA1], [SA2], [SA3], [SB1], [SB2], [SB3], each located above an area defined by the sectioned nozzles [A1], [A2], [A3], [B1], [B2], and [B3].

Fig. 9a and 9b demonstrate a method according to the invention for correcting temperature imbalances due to high and low calorific value waste and depending on the heat release profile.

Fig. 10 shows a cross-sectional view of an alternative incineration furnace-boiler or incineration device provided with a displacement body or prism [5] according to the invention, having the same features and labels as that of Figure 1a.

Fig 11 shows a three dimensional view of a furnace-boiler comprising an example of an array of temperature sensors [SA1], [SA2], [SA3], [SB1], [SB2], [SB3], and a grate supplied with several primary air injection zones, dependent on the number of grate elements and the width of the furnace-boiler installation [R1R....R5R], [R1C....R5C], and [R1L....R5L].

One aspect of present invention relates to a combustion device and method, characterized by a specific secondary air injection system in the center of the combustion zone, immediately at the combustion chamber exit and before entering the post-combustion chamber, and controlled by at least one of the following parameters: flow, turbulence, volume, composition, speed, or temperature. The secondary air is supplied into the divided flue gas streams "A" and "B" (see Figure 1a), via a secondary air supply duct [12], [13], [14] to several nozzle inlets [30] and [31] in the furnace-boiler front [6] and rear [7] wall and on both sides of the displacement body [5].

The objective of the present invention is to optimize the combustion process in an incineration system and to assure a complete combustion of the flue gases, in order to fulfill the requirements of the EU-directive (2000/076) and increase performance and lifetime of pressure part components of the incineration device. The use of this new, controlled secondary air injection system leads to more effective mixing between the oxygen supplied by the secondary air and the flue gases and will increase combustion performance. Consequently, said device and method results in a much shorter and clearly defined burn-out-zone of the flue gases in the post-combustion chamber of the furnace-boiler, a few

meters above the displacement body. The listed parameters can be adjusted according to the requirements of the incinerating process. In addition, a suitable furnace-boiler geometry can contribute to a more uniform velocity and gas flow distribution and avoid flue gas re-circulation or dead zones throughout the different sections of the furnace-boiler. Therefore, the furnace-boiler has a double venturi-like transition section between combustion and post-combustion chamber, which also promotes the mixing of the partial flue gas flows "A" and "B" with the injected secondary air. Improved mixing of the secondary air and the flue gases increases the efficiency of the combustion process.

In another embodiment, the method is characterized by the fact that the flow of the secondary air is continuously interrupted, in order to generate an additional pulsation with the secondary airflow when released in the furnace-boiler through the secondary air injection nozzles. In a more elaborated configuration, the flow of the secondary air is continuously interrupted either in the secondary air supply ducting [12], [13], [14], or in the nozzle [30], [31] or in both (see Figures 1b, 2a, 2b, 2c, 2d, 3a, 3 b, 3c).

In another embodiment, the device and method are characterized by the fact that the secondary airflow is supplied via nozzles having different cross-sectional diameters and/or by secondary air ducting, permitting different controlled secondary airflow to several zones, spread over the total width of the post-combustion chamber. According to one aspect of the invention, the diameters of the nozzles conducting the secondary air in the furnace-boiler are alternately of different size (Figure 5). This results in the injection of alternately different secondary airflow in the post-combustion chamber, initiating additional turbulence in the furnace-boiler. According to another aspect of the invention, the secondary air is supplied via a combined secondary air supply ducting [12], [13], [14] composed of two or more concentric tubes [47], [48], [49] (Figure 6). The supply of secondary air via said concentric ducts permits a more accurate control of secondary air to individual zones over the width of the post-combustion chamber. Using concentric tubes fitting in each other allows the supply of different flows of secondary air via only one single supply ducting. Different flows of the secondary air may be required depending on the stage of the combustion process in a specific zone.

Another aspect of the present invention relates to a device for waste incineration (Figure 1a), characterized by the fact that said device supplies secondary air via a secondary air duct [12], [13], [14] ending in several nozzles [30], [31] located immediately at the combustion chamber exit [3] and before entering into the post-combustion chamber [4], with

control of the secondary air by at least one of the following parameters: flow, turbulence, volume, composition, speed, or temperature.

In another embodiment, the device provides secondary air via secondary air ducting [12], [13], [14] to nozzles [30], [31], passing through the front [6] and rear [7] wall of the furnace-boiler and through the front and rear wall of the displacement body (Figure 1a). An important advantage of this design of secondary air injection is the improvement of the flue gas mixing, thanks to the reduction of the necessary penetration depth of the secondary air jet to nearly ¼ of the original furnace-boiler depth. Secondary air injection via a large number of smaller nozzles with lower individual airflow allows a much quicker heating of the secondary air to the required reaction temperature for CO-oxidation (ca. 600°C).

In another embodiment, the invention relates to said device whereby the secondary air supply ducting is composed of at least two or more concentric circular ducts. This allows supply of different flows of secondary air via only one single supply ducting. Two or more concentric ducts allow for independently controlled flows of secondary air to individual zones over the width of the post-combustion chamber, e.g. corresponding to the different grate lanes (Figure 6).

In another embodiment, the invention relates to said device where unstable flaps [20] are situated inside the secondary air supply duct or injection nozzles or both, able to create a pulsation of the secondary air when injected in the combustion chamber of the incineration device (Figure 1b). In a typical set-up (Figure 2a) the flaps have a prismatic shape and are hinged within the air supply duct or nozzle. Because of their unstable balance - as function of their weight, length or shape - and design to oscillate within an frequency range of 2 to 9 pulsations/sec = ca. 120 to 500 pulsations per minute, these flaps will disturb the laminar flow in the secondary air supply duct or nozzles and provide the secondary airflow with an additional pulsation amplitude forcing a better mixing. The frequency of the oscillation can be adjusted by a movable weight on the flaps, changing the position of the gravity center. The length of the flaps can be preferably determined as

$$\text{Minimum flap-length} = 1K \times B \sqrt{2} = f \text{ (500 pulsation's/min.)}$$

$$\text{Maximum flap-length} = 3K \times B \sqrt{2} = f \text{ (120 pulsation's/min.)}$$

$$K = \text{specific Flap-value} = f \text{ (weight, gravity center)}$$

$$B = \text{duct width at flap position}$$

In another embodiment, the invention relates to said device with pairs of separate secondary air supply ducts ending with nozzles of alternately different diameter. The

arrangement is such that the secondary air supply duct with nozzles [12] (Figure 1a) located at the furnace-boiler front wall [6] and the secondary air supply duct with nozzles situated in the front wall of the displacement body [14] form one pair. The secondary air supply duct [13] with nozzles located at the furnace-boiler rear wall [7] and the secondary air supply duct with nozzles situated in the rear wall of the displacement body [14] form another pair. In a more elaborated set-up, the device is characterized by the fact that two opposite nozzles have a different outlet diameter (Figure 5). This means that two opposite, but in-line nozzles have respectively a large [43] and a small [42] inside diameter. These different sized nozzles, facing each other, can strongly improve the mixing of the injected secondary air with the flue gases.

In a typical embodiment, the invention-related device includes a displacement body [5] with a profile of a distorted rhombus as in Figures 4 and 6.

An example of a device and method of how several parameters for secondary air injection are controlled according to the invention is illustrated in Figure 1a. The system supplies secondary air in the passages "A" and "B" by means of nozzles [30], [31] as shown in Figure 1b. The secondary air is optimally injected directly into the flow of waste gases, at the combustion chamber exit and at the entrance of the post-combustion chamber. The secondary air is injected into the divided flue gas streams "A" and "B", via a secondary air supply duct [12], [13], [14] leading to several nozzles [30], [31] located in the furnace-boiler front and rear wall and on both sides of the displacement body [5]. According to Figure 1a, furnace-boiler front [6] and rear [7] membrane wall and the membrane wall [19] of the displacement body [5] are provided with refractory materials through which a series of nozzles [30], [31] pass.

According to the invention, the total oxygen introduced into furnace-boiler as disclosed herein as primary and secondary air is determined by the oxygen content of the flue gases. The oxygen so introduced is distributed between the primary and secondary inlet systems according to methods of the art. According to the invention, the distribution primary and secondary air is attenuated by monitoring the temperatures in gas flow sections A and B as described below.

In one embodiment of the invention, a flue gas temperature measurement is installed into a furnace-boiler as described herein, a few meters above the outlet of the two flue gas streams "A" and "B," to measure the actual temperature for each flow section. In an aspect of the invention, the purpose of this temperature measurement is to maintain, during the

combustion process, nearly the same flue gas temperature (ca. 1.000°C) in front section "A" as in the rear section "B", by means of a variable secondary air flow. Consequently, when a flue gas temperature increase is observed in section "A", the secondary airflow for section "A" is increased until the equal temperature profile is automatically re-established. At the same time, secondary airflow for section "B" is reduced in order to keep the total secondary airflow constant, unless a general temperature increase is noticed in both sections whereby the total secondary airflow is increased.

In one aspect of the invention, the temperature measurement is linked to the capability of the secondary air injection system to respond to modified furnace conditions such as a shift in the heat-release profile on the grate. For instance, when high calorific waste suddenly enters the furnace, combustion of the waste will start on the first element of the grate and the flue gas temperature in section A will rise above the temperature setpoint, so shifting the heat release profile towards the feeding hopper. The setpoint may be any temperature defined by the user. The set point temperature may be a value in the range of 900 to 1100 °C, 950 to 1050 °C, 920 to 1020 °C, 970 to 1070 °C, 980 to 1080 °C, 970 to 1030 °C, 980 to 1020 °C or 990 to 1010 °C. The system recognizes the over-temperature and the temperature imbalance and reacts accordingly as described above. A similar process, but in the opposite direction will occur when low calorific waste is introduced and combustion on the grate is delayed. This is exemplified in Figure 9a, wherein a temperature sensor [91], [92] is placed in each of the flue gas streams above the displacement body [5]. When high calorific value waste [93] enters the furnace, the temperature of the gas in flue stream A increases, so raising the temperature detected by the sensor [91] placed over stream A above the set point. The increase in temperature and the imbalance causes more secondary air to be injected from the nozzles below the hotter stream of air [94], and also less secondary air to be injected from the nozzles below the cooler stream of air [95].

In Figure 9b, when lower calorific value waste [96] enters a furnace as disclosed herein, the heat release profile shifts slightly away from the hopper and towards the exit [901]. There is a slight increase in temperature of the gas in flue stream B, so raising the temperature detected by the sensor [92] placed over stream B above the set point. The increase in temperature and the imbalance causes more secondary air to be injected from the nozzles below the hotter stream of air [97], and also less secondary air to be injected from the nozzles below the cooler stream of air [98].

In another aspect of the invention, the detection of the temperature in the gas flow sections A and B is used as a pre-indication of the type of waste entering the furnace, and may be connected to the process control of the grate speed and primary air distribution along the different grate elements. For instance, as in Figure 9a, when high calorific waste [93] enters a furnace as disclosed herein, combustion of the waste will start on the first element of the grate and the heat release profile of the grate will be shifted towards the waste input (hopper) end [99] of the grate. The consequence is that waste will be incinerated towards the waste input end of the grate [99]. According to the invention, the shift of heat release profile is detected by the flue gas temperature sensor in section A [91], which would rise above the temperature setpoint. The setpoint may be any temperature defined as described above. The system detects the over-temperature and recognizes the temperature imbalance between section A and section B, and reacts by decreasing the supply of primary air beneath or proximal to the high calorific waste [R1 to R2] so as to shift the heat-release profile back towards to the region of the post-combustion chamber. At the same time, the primary airflow in the remaining positions of the grate [R3 to R5] is increased in order to keep the total primary airflow constant. A similar process, but in the opposite direction will occur when low calorific waste is introduced, and combustion on the grate is delayed, so shifting the heat release profile in the direction of the waste output [901] (Figure 9b).

As described above, the nozzles for injecting secondary air are positioned in two pairs of rows, each row on an opposite wall. One pair of walls is formed by the furnace-boiler inner front wall and the opposing displacement body wall; another pair of walls is formed by the furnace-boiler inner rear wall and the opposing displacement body wall. According to one aspect of the invention, each row of secondary air nozzles is divided into two or more segments, each segment comprising two or more nozzles, such that the flow of air through any one segment can be the same or different from that of directly adjacent segments. An air flow in one segment may be controlled by one or more valves, by modulating one or more air fans, by controlling the nozzle diameters within a certain range, or a combination of these. It is within the scope of the invention that the diameters of the nozzles belonging to a segment are the same or are alternately of different sizes such as that shown in Figure 5. It is within the scope of the invention that the diameters of the nozzles belonging to a segment are placed opposite to nozzles of the same diameter on the corresponding opposing wall. It is further within the scope of the invention that the diameters of the nozzles belonging to a segment are placed opposite to nozzles of a different diameter on the corresponding

opposing wall. When placed opposite nozzles of a different diameter, it is within the scope of the invention that the nozzles of small diameter nozzles are placed opposite to nozzles having a larger diameters.

An example of a furnace-boiler comprising rows of secondary air nozzles divided into
5 three segments is given in Figure 7. Figure 7 shows one pair of rows of secondary nozzles [71], [72] divided into three separate segments [73], [74], [75] Control of secondary air thereto is achieved by means of a valve [77] controlling the air flow to each segment, and a valve [78] controlling the air flow to each row of nozzles.

According to one aspect of the invention, an array of temperature sensors is installed
10 a few meters above the outlet of the two gas flow sections "A" and "B" to measure the actual temperature for each flow section. According to another aspect of the invention, the number of temperature sensors installed is equal to the number of segments that each pair of rows of nozzles is divided into. According to another aspect of the invention, the array of sensors positioned in each of the two gas flow sections "A" and "B", such that each sensor is placed
15 above and in the vicinity of an area defined by a segment of nozzles along one wall, the corresponding segment of nozzles along the opposite wall and the distance between the rows of nozzles. For the purposes of this document, the area defined by a segment of nozzles along one wall, the corresponding segment of nozzles along the opposite wall and the distance between the rows of nozzles is known as the "segment injection area". Figure 8
20 shows an example of a furnace-boiler according to the present invention having an array of temperature sensors [81] placed above the displacement body [5]. The segment injection areas as described above are labeled [A1], [A2] and [A3], defined by the nozzle segments [73], [74], [75]. Temperature sensors [SA1], [SA2] and [SA3] are placed above and in the vicinity of the respective segment injection areas [A1], [A2] and [A3]. A similar arrangement of
25 temperature sensors [SB1], [SB2] and [SB3] is placed above and in the vicinity of the segment injection areas of the other passage ("B"), said segment injection areas labeled by [B1], [B2] and [B3]. The "vicinity" of the segment injection areas may be determined by extrapolating the positions and sizes of the segment injection areas at the narrowed entrance of the post-combustion chamber to the cross-section of the post-combustion chamber. This
30 extrapolation is performed using methods of the art.

A precise control of the temperature of the air in the post-combustion chamber is important for minimizing the effects of corrosion, slagging and fouling. The inventors have found that differences in temperature exists within each section of the post-combustion

chamber, *e.g.* the temperature across section A might be found to be hotter in the middle compared with the edges. The inventors have found that the differences can be partially or completely modulated by changing the rate of injection (flow) of secondary air in the region below the local temperature difference, so leading to a reduction in corrosion, slagging and fouling in the post-combustion chamber and in the boiler. In another aspect of the invention each pair of rows of nozzles is divided into one or more segments as described above, and each temperature sensor of the array is placed above and in the vicinity of each segment injection area; in this arrangement, the temperature detected by each sensor determines the rate at which air is injected by the corresponding segments of nozzles. For example, in Figure 8, the air flow from nozzles [74] in an indicated segment injection area [A2] is determined by the reading of sensor [SA2]; the air flow from nozzles [73] in an indicated segment injection area [A1] is determined by the reading of sensor [SA1]; the air flow from nozzles [75] in an indicated segment injection area [A3] is determined by the reading of sensor [SA3]. It was the unexpected finding by the inventors that local temperature fluctuations in the post-combustion chamber could be modulated by the position and rate at which secondary air is introduced into the furnace-boiler (in other words the flow of secondary air). This unexpected finding has meant that the effect of the cooled furnace-boiler walls may be compensated for. Furthermore, any temperature unevenness in the post-combustion chamber due to heterologous loading across the grate lane caused, for example, by the presence of high calorific value material at the edges of the grate, or by a greater mass of material in the center of the grate can be compensated for.

The inventors have further found that the differences in temperature within each section of the post-combustion chamber as described above, can be partially or completely modulated by changing the primary air flow in the region below the local temperature difference. This is illustrated in Figure 11, which illustrates a three-dimension view of a furnace-boiler according to the present invention having a displacement body [5] and an array of temperature sensors [SA1], [SA2], [SA3], [SB1], [SB2] and [SB3]. The input of primary air is controllable along the different grate elements [R1] to [R5] and across the width of the grate [R_R], [R_C], and [R_L]. In one embodiment of the invention, the furnace comprises a two dimensional matrix of primary air input zones, along the grate and across the width of the grate. In another embodiment of the present invention, the temperature change detected by the array of temperature sensors in the post-combustion chamber influences the primary air flow across the width of the grate. In another embodiment of the invention, a temperature

sensor that indicates an increase in temperature, causes a reduction in flow in one or more the primary air input zones located below the position of said sensor. For example, should sensor [SA1] detect an increase in temperature, the corresponding primary air entrance zone located below [SA1] would respond by reducing the flow of air [R1L] and/or [R2L] and/or [R3L]. The air flow in the remaining primary air entrance zones is increased so as to maintain the correct total air supply.

The device and method as disclosed herein also reduces the corrosion potential, by minimizing the CO-concentration (reducing atmosphere) in the flue gas flow in presence of HCl, Cl and Cl-combination.

A considerable reduction of dust carry-over from a furnace according to the invention into the combustion and post-combustion chamber of the incineration device is obtained using this method and device, because overall less primary air is required under the grate. An additional advantage of the system is that the combustion process is fully completed 2–3 m above the displacement body and no flame breakouts occur in the upper section of the post-combustion chamber. The nearly complete burn-out above the displacement body, the even flue gas temperature distribution and absence of hot gas layers together with the reduced dust carry-over with the flue gases, leads to reduced fouling of the furnace-boiler heating surfaces. As the fouling tendency of the furnace-boiler heating surfaces is much lower, an important increased period between shutdowns for manual cleaning can be achieved. Consequently, this results in a reduction of the maintenance and repair expenses in general and simultaneously increase installation availability

The refractory lining extent in the first pass can be reduced to the strict minimum, just enough to comply with the two seconds/850°C rule. Furthermore, as the burnout is fully completed a few meters above the displacement body, there is no further need to protect the membrane walls of the post-combustion chamber and first pass above this level.

According to one embodiment of the present invention, the supply of secondary air is continuously disturbed with the purpose of creating a pulsation of the secondary air before entering the furnace-boiler. According to Figure 1b, this pulsation can be produced by means of unstable flap [20], placed in the secondary air supply ducts [12], [13], [14] as shown in Figure 1b. A main secondary air duct [16] feeds said secondary air supply ducts [12], [13], [14]. The permanent movement of the flap 20 will create a pulsating secondary air flow in the area of both restrictions of section "A" and "B".

Figures 2a, 2b, 2c and 2d explain in detail the action of the constant moving flap 20 in a hinged configuration. Figure 2a shows a self-moving oscillating flap [20] without external drive. The oscillation amplitude of these self-moving flaps is depending upon the length, the shape and the weight of the flaps. In case of rotating valves, an oscillating impulse strength can be realized in a single nozzle as explained in Figure 3a, with an external driven (such as an electric motor M) rotating circular valve [20]. Externally driven valves [20] can be located within the individual nozzles [30], [31], as shown in Figure 3b, or within the common secondary air supply ducts [12], [13], [14] as shown in Figure 3c. The location of the valves [20], respectively in the secondary air supply ducts [12], [13], [14] as shown on Figure 3c, or in each individual nozzle [30], [31], as shown in Figure 3b, has a different influence on the oscillation impulse of the nozzles.

It is within the scope of the present invention that the means to pulsate air as described above may be installed in any furnace-boiler according to the present invention.

Figure 1a shows the cross section of the furnace-boiler, combustion and post-combustion chamber of a typical incinerator arrangement, particularly designed for incineration of solid waste or biomass, consisting of a furnace [2] with an incineration grate [25], receiving the solid materials through a feeding hopper with pusher [1]. The produced flue gases are conducted in a combustion chamber [3] and a post-combustion chamber [4]. Hoppers [22] underneath the grate [25], are placed for collection of the siftings of the grate and serving at the same time as primary air supply channels. The primary air is supplied via several air ducts [23]. At the end of the grate [25], the ashes fall via a shaft [21] into an ash extractor (not shown). The produced flue gases, not yet completely burned out, are divided in two streams by a displacement body [5], installed at the entrance of the post-combustion chamber [4]. By placing the displacement body [5] at the combustion chamber exit [3] and the entrance into the post-combustion chamber [4], the flue gases passage is divided in two flow channels "A" and "B". Secondary air is injected through four rows of nozzles located at the entrance of the post-combustion chamber [4] where the displacement body [5] is located. The secondary air is conducted via nozzles [30] in the front [6] and rear wall [7] of the furnace-boiler as well as via nozzles [31] of the displacement body [5]. The flue gases are mixed with secondary air, resulting in an almost complete burnout of the flue gases a few meters above the displacement body [5] and also resulting in shorter flames and more uniform oxygen concentrations. The secondary air is supplied by a secondary air fan [9] via secondary air

ducts [11], provided with secondary air regulating valves [15], to the secondary air supply ducts [12], [13], [14] into the injection nozzles [30], [31].

Alternatives and possible set-ups of the invention are illustrated in Figures 5, 6, 7, 8 , 11 and 12. Figure 5 discloses two secondary air supply ducts, aligned in parallel, and nozzles [42], [43] with alternate different diameter. Two opposite nozzles have respectively a large [43] and a small diameter [42] in order to improve the mixing of the injected secondary air with the flue gases. Figure 6 illustrates the use of different concentric ducts [47], [48], [49], to supply secondary air to duct [14]. Due to the fact that three concentric tubes [47], [48], [49] are provided, three different flows of secondary air can be independently controlled and injected over the total width of the furnace-boiler.

Claims

1. Device for incineration of solid materials comprising:

- a feeding system able to introduce the solid materials in a furnace,
- 5 - a grate system comprising several grate elements,
- a furnace able to incinerate said solid materials,
- a post-combustion chamber able to burn out the produced flue gases resulting from said incineration,
- a primary air supply system capable of differentially distributing air across different
- 10 grate elements and across the width of the grate,
- a displacement body placed at the combustion chamber exit and entrance of the post-combustion chamber able to split the produced flue gas flow in two separate flue gas streams,
- a bend in such shape of the device inner front and rear walls, that together with the
- 15 outline of the displacement body creates two venturi-shaped flue gas passages at the inlet of the post-combustion chamber,
- two pairs of rows of secondary air injection nozzles located immediately at the combustion chamber exit and entrance of the post-combustion chamber, one pair located on furnace inner front wall and the opposing displacement body wall; another
- 20 pair located on the furnace inner rear wall and the opposing displacement body wall,

characterised in that each row of secondary air injection nozzles is divided into two or more segments, each segment comprising two or more nozzles, such that the flow of air through any one segment is capable of being different from that of directly adjacent

25 segments.

2. A device according to claim 1 wherein each segment and segment opposite thereto form pairs of segments on opposite pairs of rows of secondary air nozzles.

30 3. A device according to claims 1 and 2 wherein the air flow to each segment is controlled by one or more valves and/or by modulating one or more air fans and/or according to the selected diameters of the secondary air injection nozzles within said segment.

4. A device according to any of claims 1 to 3 wherein
- each segment, and segment located opposite thereto contains a larger and smaller diameter of said nozzles,
 - nozzles having the larger diameter are adjacent to the nozzles having a smaller diameter
- 5 within said segments
- the nozzles are aligned in opposing segments such that those of the larger diameter are placed directly opposite nozzles having the smaller diameter.
- 10 5. A device according to any of claims 1 to 4 further comprising any array of four or more temperature sensors, each sensor located above an area defined by a pair of segments.
6. A device according to any of claims 1 to 5 whereby the secondary air is provided via secondary air supply ducts ending in injection nozzles, passing through the front- and rear-wall of said device as well as through the membrane-wall of the displacement body.
- 15 7. A device according to any of claims 1 to 6 whereby, the secondary air supply duct consists of two or more concentric ducts, inside of the displacement body or along the exterior of the furnace-boiler walls.
- 20 8. A device according to any of claims 1 to 7 whereby the inner front and rear walls of said device are bent in such shape that, together with the outline of the displacement body, two venturi-shaped flue gas passages with opening angles α and β according to Figure 4 between 20° and 40° are created in order to increase the flue gas turbulence in the venturi-shaped mixing zone.
- 25 9. A device according to any of claims 1 to 8 wherein the displacement body is made in the shape of a distorted rhomboidal prism.
10. A method for incinerating solid materials comprising the use of a device according to any
- 30 of claims 1 to 9.
11. A method according to claim 10 further comprising the steps of
- a) monitoring the oxygen content of the flue gases,

- b) determining from step a) the total air flow required by said device,
- c) distributing air to the primary and secondary air supply systems such that the total air flow is maintained according to step b),
- d) monitoring the temperature of each temperature sensor,
- 5 e) averaging the temperature of the temperature sensors located in each flue gas stream,
- f) comparing the averaged temperatures of step e) to determine the hotter of the two gas streams,
- g) increasing the flow of secondary air through the secondary air nozzles located below the hotter of the two gas streams, and decreasing the flow of secondary air in the nozzles located
- 10 below of the cooler of the two gas streams, so maintaining overall the same total of air flow in the secondary air system, and
- h) not changing the flow of secondary air if both gas streams have the same temperature according to step f), so maintaining overall the same total of air flow in the secondary air system.

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12. A method according to claims 10 and 11 further comprising the steps of:

- i) decreasing the flow of primary air beneath the grate elements proximal to the feeder system, when the hotter of two gas streams determined in step f) is located proximal to the feeder system, and increasing the flow of primary air in the area beneath the remainder of
- 20 the grate elements, so maintaining the same total of air flow in the primary air system,
- j) increasing the flow of primary air beneath the grate elements proximal to the feeder system, when the hotter of two gas streams determined in step f) is located proximal to the output system, and decreasing the flow of primary air in the area beneath the remainder of the grate elements, so maintaining the same total of air flow in the primary air system,
- 25 k) not changing the flow of primary air if both gas streams have the same temperature according to step f), so maintaining the same total of air flow in the primary air system.

13. A method according to any of claims 10 to 12 further comprising the steps of:

- l) comparing the temperature of each temperature sensor monitored in step d) with the
- 30 average determined in step e),
- m) increasing the flow of secondary air in both segments with secondary air nozzles located beneath the sensor detecting a temperature hotter than the average determined in step e),

and decreasing the flow of secondary air to the other segments, so maintaining the same total of air flow in the secondary air system,

n) decreasing the flow of secondary air in both segments with secondary air nozzles located beneath the sensor detecting a temperature lower than the average determined in step e),

5 and increasing the flow of secondary air to the other segments, so maintaining the same total of air flow in the secondary air system,

o) not changing the flow of secondary air if the temperatures detected by the sensors are the same as the average determined in step e), so maintaining the same total of air flow in the secondary air system.