

TITLE

A Honeycomb Grate Incinerator

ABSTRACT

A honeycomb grate incinerator includes a furnace jacket (10), a lining (30) and honeycomb grates (20). The lining (30) and the honeycomb grates (20) are disposed in the furnace jacket (10), and each of the honeycomb grates (20) has a hollow passage (21). The outer end of each honeycomb grate (20) is in contact with the inner surface of the furnace jacket (10), and the inner end of each honeycomb grate (20) has several gas outlets (22) for connecting the hollow passage (21) with a furnace chamber (12). The hollow passage (21) is then interconnected with gas inlets (11) in the furnace jacket (10).

FIELD OF INVENTION

The present invention relates to an incinerator, particularly a honeycomb grate incinerator.

TECHNICAL BACKGROUND

The furnace grates used by many incinerators today can be categorized under the steel-reinforced grate, chain grate, boiler grate with hood, mechanical reciprocating grate and rolling grate models. There is a shortcoming for an incinerator using any of the aforementioned grates, and that is, the incinerator cannot burn and dispose municipal solid waste (MSW) completely. For example, after the slag of organic waste water are compressed and dried, their particle size become very small; and for the slag of organic waste water which are not burnt, the small sized particles will drop into the slag of the incinerator through the gaps in between grates, thereby causing pollution. Furthermore, the gaseous dioxins (PCDDs, PCDFs) and harmful substances inside the furnace chamber cannot be easily removed. And the cadmium in the slag is also difficult to remove.

An improved method is to use a twin rotary furnace to incinerate. The equipment comprises of a horizontal and vertical rotary furnace. In the first stage, the horizontal rotary furnace is used to perform waste combustion under starved oxygen conditions; the furnace is heated up without a visible flame; the temperature of the furnace is kept under 600 °C to facilitate the generation of combustible gases. In the second stage, the vertical rotary furnace is used; it receives the combustible gases (with temperature less than or equal to 600 °C) and the carbonized waste created in the horizontal rotary furnace, and proceed on with the combustion of waste with a visible flame; the temperature of this furnace can reach to as high as 1350 °C. This combustion method is known as gasified combustion and it is more advanced, able to achieve total combustion of MSW and reduce pollution significantly. The gasified combustion has already been accepted by the United Nations CDM Executive Board. A waste incineration project which utilizes the gasified combustion method can be registered as a CDM project, and adopts the AM0025 <<Baseline and Monitoring Methodology>>.

Although the aforementioned twin rotary furnace approach can resolve the pollution problems incurred by waste combustion, it is very costly to operate and invest in the two furnaces and the equipment to transport inflammable gases and carbonized waste materials at temperatures of less than or equal to 600 °C.

OBJECTS OF INVENTION

The primary objective of our invention is to provide a honeycomb grate incinerator to resolve the aforementioned environmental pollution problems and the shortcomings of current incinerators. In other words, the invention can accomplish total combustion of MSW and resolve the issues of environmental pollution with one piece of equipment. There is also zero emission of dioxins, and zero pollution issue with non-combusted sedimentary waste from waste water treatment. The incineration project can register to become a CDM project with the

United Nations Clean Development Mechanism (CDM) Executive Board. The investment in equipment is substantially reduced, and the operating cost is also significantly lowered. The invention is particularly applicable to the more advanced gasified combustion method for burning MSW.

The objectives of the invention are achieved by adopting the following technical solutions.

The invention is a honeycomb grate incinerator with a furnace jacket. The unique features of the invention are: the lining, the honeycomb grates and the said furnace jacket forms the furnace body and the said lining is laid along and around the inner surface of the furnace jacket. The said honeycomb grate encloses a hollow passage, and the external surface of the honeycomb grate is in contact with the inner surface of the furnace jacket. The inner surface of the honeycomb grate is perforated with many gas outlets, which connect the hollow passage in the honeycomb grates to the furnace chamber and the hollow passage is also linked to the gas inlet on the furnace jacket.

The said honeycomb grate is composed of several honeycomb grate bricks. There are hollow channels enclosed in the said honeycomb grate brick, which lead to the gas outlets found on the inner surface of the grate brick itself. The outer surface of each said honeycomb grate bricks is laid round the axial interior of the furnace jacket to form a honeycomb grate structure with hollow air passageway and gas outlets.

The said grate brick is composed of two grate units.

There are inter-connecting ventilation grooves and as inlets found on the external surfaces of the said honeycomb grate and lining. Each of the said ventilation groove is also directly linked to the hollow passage of the honeycomb grate.

In the said incinerator, the furnace chamber has a number of combustion chambers.

The first combustion chamber, second combustion chamber and the third combustion chamber are arranged in sequential order from the front to the rear end of the furnace jacket of the said incinerator. There are the said honeycomb grates in the first and second combustion chambers. The external surfaces of the corresponding honeycomb grate and the lining found at the furnace jacket's gas inlet locations contain ventilation grooves, and the ventilation groove is connected to the hollow passage and the gas inlet. The hollow passages between the first and second combustion chambers are separated.

The axis of the said incinerator makes an inclined angle with the horizontal. The sine value of the angle ranges from 3% to 4%.

At the front end of the said incinerator, there is a nozzle spout for spray-injecting pulverized lime.

The invention uses the honeycomb grate, which revolutionises the method of transporting air to the furnace. It gets air passing through the gas inlet and ventilation groove distributed to the various combustion chambers located at different sections of the furnace chamber. In addition, the amount of air entering the combustion chambers can be regulated. To replace the original twin (one horizontal + one vertical) rotary furnace in waste combustion, we propose the following. For example, in the invention, the first segment of the furnace chamber (the first

combustion chamber) performs gasified combustion of waste under deprived oxygen conditions, and in the process, combustible synthetic gases are produced. In the second segment (the second combustion chamber), we burn the synthetic gas to continue with the waste combustion. Other than replacing the original twin rotary furnace, the invention does not require expensive alloy conveyer equipment and facilities to transport the combustible synthetic gas and the carbonized waste between furnace segments, and this substantially decreases the manufacturing costs. For the furnace structure, honeycomb grates are used. Through the gas inlets and ventilation grooves, air can be delivered to the different combustion chambers; and by controlling the temperature and the amount of air, we can ensure the amount of delivered air is in accordance with the technical requirements of the combustion process, just right to heat under starved oxygen conditions and burn synthetic gases. The total waste combustion step occurs in the third combustion chamber, which uses the combustion air left behind after all the burning in the preceding combustion chambers, to completely burn the rubbish waste and to eradicate the dioxins in the exhausts and the cadmium in the slag. The use of a specially designed grate brick facilitates the installation of the masonry. The said grate brick can be assembled from grate units that are mass produced by molding. By using honeycomb grate bricks to construct the honeycomb grate, the installation, maintenance and replacement of parts become easier. The invention can work accordingly under the temperature conditions and time-curves set forth in the process requirements, achieving total combustion of MSW and resolving the issues of environmental pollution. The number of equipment is reduced to one and the equipment structure is also uncomplicated.

In summary, by adopting our invention, one can accomplish the total combustion of MSW, avoid environmental pollution and achieve positive environmental effects. There are fewer machinery parts, thus its investment in equipment is low; besides, its structure is also simple to build. Since grate units that are mass produced by molding are used to assemble into grate

bricks, the installation, maintenance and replacement of these bricks are hassle-free and uncomplicated to perform. This leads to a substantial reduction in the investment and operating costs. The invention can comply in accordance with the technical requirements of any combustion processes, but it is especially suitable for the gasified combustion method of burning waste.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is the set-up and installation diagram of the invention.

Fig. 2 is the schematic of the furnace body used in the invention.

Fig. 3 is the enlarged diagram of the section A-A in Fig. 1 (parts 70, 70A not shown), and the section A-A in Fig. 2.

Fig. 4 is the enlarged diagram of the section B-B in Fig. 2.

Fig. 5 is the enlarged diagram of the section C-C in Fig. 2.

Fig. 6 is the enlarged diagram of the section D-D in Fig. 3.

Fig. 7 is the enlarged diagram of the section E-E in Fig. 4.

Fig. 8 is the enlarged diagram of the section F-F in Fig. 3.

Description of codes used in the figures:

- 10 furnace jacket
- 11 gas inlet
- 12 furnace chamber
- 12A first combustion chamber
- 12B second combustion chamber
- 12C third combustion chamber
- 13 feed inlet
- 14 waste vent

15	exhaust
20	honeycomb grate
20A	grate brick
20B	grate unit
20C	external portion
20D	grate unit assembly interface
21	hollow passage
21A	air passageway
22,22A	gas outlet
23	fender brick
30	lining
31	ventilation groove
32	connecting vent
40	nozzle
50	gyratory unit
60	actuator unit
61	motors
62	decelerators
63, 64	rotary gears
70	first air intake unit
70A	second air intake unit

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 and 2 show the set-up and installation diagram of the invention, i.e., the honeycomb grate incinerator. The furnace jacket (10) is supported by the gyratory unit (50) and through the collaborative actions of the motors (61), decelerators (62) and rotary gears (63), (64) found

inside the actuator unit (60), the furnace jacket (10) is propelled to turn. The feed inlet (13) and the nozzle (40) are located at the front part of the incinerator, while the waste vent (14) and exhaust (15) are located at the rear. Feedstock is fed through the feed inlet (13), and discharged out of the incinerator through the waste vent (14) after combustion. The first air intake unit (70) and the second air intake unit (70A), which are separately located on the furnace jacket (10), drive air into each gas inlet (11) found on the furnace jacket. The said incinerator is installed with its front end slightly higher than its rear end, and inclined with respect to the horizontal. The words “front” and “back” cited in this patent draft refer to the front (left side of Fig. 1) and rear (right side of Fig. 1) end of the incinerator respectively. In addition, the words “inner side” and “outer side” refer to the side which is closer to, and to the side that is further away from the central axis of the incinerator.

As shown in Fig. 3, 5 and 6, the said furnace jacket (10) is laid with a lining (30) and honeycomb grates (20), and collectively, they formed a furnace body:

The said honeycomb grate (20) is a grate with a hollow passage (21). The outer side of the honeycomb grate (20) is in contact with the inner side of the furnace jacket (10). The section of the inner side of the honeycomb grate, which is slightly above the lining (30), is perforated with multiple gas outlets (22). These gas outlets connect the said hollow passage (21) to the furnace chamber (12). The hollow passage (21) is also connected to the gas inlet (11) of the furnace jacket (10) (via the ventilation groove (31)) – air enters the gas inlet (11) and arrives at the hollow passage (21); it is then distributed to each combustion chamber of the furnace chamber (12) through the multiple gas outlets (22) to regulate the temperature of each combustion chamber).

As shown in Fig. 6, the said honeycomb grate (20) is composed of numerous grate bricks (20A). The said grate brick (20A) encloses an air passageway (21A). The gas outlets (22A) located on the inner surface of the grate brick (20A) is connected to the air passageway (21A) and the furnace chamber (12). The outer surfaces of the said grate bricks (20A) are laid round the axial interior of the furnace jacket (10) to form the honeycomb grate (20) that contains the hollow passage (21) and gas outlets (22). The front and back ends of the hollow passage (21) are sealed.

The honeycomb grate brick (20A) shown in Fig. 6 is composed of two grate units (20B) joined at the interface (20D) (shown by the hypothetical line in Fig. 6). Owing to considerations given to convenience in mass production by molding, and improved productivity accompanied with high yield, the grate units are made symmetrical (or repeating in structure and shape). When in use, aligned and joined the two symmetrical grate units (20B) together to form a grate brick (20A).

As shown in Fig. 3 and 6, there are ring-shaped ventilation grooves (31) present on the exterior surfaces of the said honeycomb grate (20) and lining (30), and they are interconnected to the gas inlets (11). Each of the said ventilation grooves (31) is also directly connected to the hollow passage (21) of the honeycomb grate (20). During installation of the masonry, remove an exterior portion of the honeycomb grate brick (20A) (shown by the hypothetical line in Fig. 6), enough to expose the enclosed hollow passage (21) and allow it to form a direct airway with the ventilation groove (31).

As shown in Fig. 1 and 2, the furnace chamber (12) houses several combustion chambers. In the incinerator we used, the first combustion chamber (12A), second combustion chamber (12B) and the third combustion chamber (12C) are arranged in sequential order from the front

to the rear end of the furnace chamber (12). There are honeycomb grates (20) in the first and second combustion chambers. Both the front and back ends of the hollow passage (21) in the honeycomb grate (20) are sealed. Between the first (12A) and second (12B) combustion chambers, fender bricks (23) are used to separate the hollow passage (21) (see Fig. 1); in the first combustion chamber (12A), there are fewer gas inlets (11) and their primary function is to supply air into the furnace to heat up the furnace to produce combustible synthetic gas (or syngas). The honeycomb grate (20) and the lining (30) at this location have ring-shaped ventilation grooves (31) (see Fig. 3 and 6) on them. In the second combustion chamber (12B), there are more gas inlets (11) and their primary function is to supply air to burn the synthetic gas. The honeycomb grate (20) and the lining (30) at this location also have ring-shaped ventilation grooves (31) on them. As shown in Fig. 8, there is an axial vent (32) bridging two adjacent ring-shaped ventilation grooves (31). As shown in Fig. 4 and 7, there are also regions in the first (12A) and second (12B) combustion chambers where there are no gas inlets (11). The honeycomb grate (20) and the lining (30) at these locations do not have ring-shaped ventilation grooves (31) on them. Henceforth, the air outside the furnace jacket (10) cannot directly enter the hollow passage (21) of the honeycomb grate located here. Instead, the air enters from a distant gas inlet (11), and travels a certain distance inside the hollow passage (21) of the honeycomb grate (20) before it reaches here. Eventually, it enters the furnace chamber (12) via the gas outlets (22) found at these locations. In the third combustion chamber (12C), there is only the lining (30) and no honeycomb grate (20).

As shown in Fig. 1 and 2, the said incinerator is installed with its front end slightly higher than its rear. The inclined angle θ between the central axis of the said incinerator and the horizontal registers a sine value of 3% to 4%.

As shown in Fig. 1, there is a nozzle (40) located at the front end of the said incinerator. The nozzle (40) sprays pulverized lime to react and neutralize the hydrogen chloride (HCl) present in the gaseous by-products, in order to get rid of the dioxins.

A description of the furnace in operation (the length of the furnace used in this case study is 26 metres):

1. Gasification (under oxygen deficiency condition) in the first combustion chamber (12A):

The amount of combustion air delivered to this chamber is controlled to around 25% of the total amount of combustion air, which is lower than the theoretical amount of combustion air needed to produce a visible flame. When the combustion temperature reaches 450 °C ~ 600 °C, the waste is dried and decomposed by gasification, and in the process, generates large amounts of combustible gases (contain hydrocarbons), which flow to the second combustion chamber (12B). The gasification conversion rate in the first combustion chamber is approximately 65%.

The Heat source: Diesel oil is injected and ignited to heat up the furnace. When the temperature of the furnace reaches 800 °C and above, the rubbish waste is fed. When the combustible gases produced from waste gasification and decomposition enters the second combustion chamber to proceed on with the visible flame combustion, a portion of the thermal energy generated from this combustion is circulated back to the first combustion chamber.

2. Gasification (under oxygen deficiency condition) and Visible Flame Combustion in the second combustion chamber:

a) *Gasification (under oxygen deficiency conditions):* The decomposed waste from the first combustion chamber travels downstream owing to the gyratory motion of the rotary furnace. When this decomposed waste reaches the second combustion chamber, it always sinks to the

bottom half of the furnace chamber (12). There are honeycomb grates (20) with gas outlets (22) distributed equally around one round of the second combustion chamber. The accumulated waste at the bottom of the chamber will be blocking the gas outlets (22) (the small openings which transport air from the outside into the furnace chamber) of those honeycomb grates located at the bottom half of the second combustion chamber, resulting in the bottom half of the furnace chamber (12) to be in a starved oxygen state. Gasification of waste decomposes to produce combustible gases. The cumulative gasification conversion rate in the first and second combustion chamber is greater than or equal to 90%.

b) *Visible flame combustion:* The amount of combustible air entering the second combustion chamber is about 75% of the total amount of combustion air. This air injects into the second combustion chamber, without obstruction, from the gas outlets (22) found on the upper half of the honeycomb grates (20). This ample amount of combustible air, upon interaction with the combustible gases, reacts exothermically and raises the temperature of the chamber to be at least 1200 °C. The temperature of the combustion air stream delivered to the furnace chamber is less than or equal to 220 °C; as a result, the temperature of the furnace chamber is lowered and maintained steady at around 1000 ~ 1080 °C.

3. Surface Combustion in the third combustion chamber (12C):

Accompanying the gyrating motion of the rotary furnace, the carbonized waste enters the third combustion chamber. No fresh air is drawn into the third combustion chamber. Only the residual combustion air that enters into the chamber is used to burn the rubbish waste completely. The temperature of the third combustion chamber is at least 900 °C, and the temperature of the rear end of the incinerator which discharges flue gases and exhausts is at least 850 °C. The carbon-content remaining in the slag is less than 1%.

The waste incineration time inside the furnace lasts about 90 minutes. The flue gases stay inside the furnace chamber for more than 2 – 3 seconds.

The slag is discharged from the furnace via the waste vent (14) located at the rear end of the furnace. The slag enters the screw conveyor unit, and the design of the screw blade of the conveyor unit is double-layered and centre-hollow. Cool water enters the “centre-hollow” section first and then flows out to cool the slag. At the same time, the slag in the screw conveyor unit will be blocking air from the outside, preventing it from infiltrating the furnace, leading to “leakage”.

The high-temperature flue gases and exhausts generated from waste combustion inside the furnace are discharged from the exhaust outlet. They are routed back into the boiler via the gas pipes, and absorbed for use to produce steam and hot water.

ADVANTAGES OF INVENTIONS

(1) Zero dioxin emission.

The honeycomb grates (20) repeatedly bring the waste inside the furnace chamber (12) to certain elevations so that they (the waste) free-fall under effect of gravity, combustible air enters the chamber from numerous small gas outlets in different directions, creating tremendous turbulence in furnace chamber, under these circumstances, the waste inside the furnace chamber is burning under mild turbulent conditions. Pulverized lime is spray-injected into the furnace from the nozzle spout (40) located at the front end of the incinerator, the lime reacted with the gaseous hydrogen chloride (HCl) present in the furnace to form calcium chloride (CaCl_2) and calcium sulfate (CaSO_3) salts, which are discharged out as slag. The gaseous hydrogen chloride (HCl) is cleared continuously. Owing to an absence of gaseous

hydrogen chloride (HCl) in the environment, dioxin cannot be created. Dioxin is formed when a hydrogen (H) atom of a benzene molecule (CH_6) is replaced by a chlorine atom (Cl) from a hydrogen chloride (HCl) molecule. The chlorine (Cl) atom can displace any of the 6 hydrogen (H) atom in the benzene (CH_6) molecule, and 2 or more hydrogen (H) atom in a benzene (CH_6) molecule can be substituted if more chlorine (Cl) atoms are present. In total, 210 compounds can be generated, with 75 isomers being Polychlorinated Dibenzo-*p*-dioxins (PCDDs), 135 isomers being Polychlorinated Dibenzofurans (PCDFs) and collectively, they are known as dioxins. Owing to the continuous removal of gaseous hydrogen chloride (HCl) in the furnace chamber, chlorine (Cl) atoms would be absent and hence, dioxins cannot be formed.

(2) No cadmium found in waste slag.

The gasification temperature of cadmium is 767 °C, and the combustion of waste takes place at 900 °C – 1080 °C (due to the gyrating motion of the rotary furnace, the waste inside the furnace is churned continuously to maintain a uniform temperature in the furnace chamber), the cadmium is gasified to become a gaseous state, and it follows the flue gases downstream to the exhaust cleaning system, where it is adsorbed by the activated carbon that are spray-injected into the exhaust cleaning system. The contaminated activated carbon will be collected in filter bags (which are subsequently buried after solidification). The waste slag does not contain cadmium, and the carbon-content remaining in the slag is also less than 1%.

The carbon-content found in the waste slag produced by other grate incinerators presently used in China is greater than or equal to 3.5%. The baseline and monitoring methodology (AM0025) approved by the United Nations CDM Executive Board requires that, for non-gasified waste combustion incineration project, the carbon-content in the waste slag must be less than or equal to 1% before it can register to become a CDM project. The existing waste incineration technologies used in many China's waste incineration engineering projects produced waste

slag with carbon-content greater than or equal to 3.5%; therefore, they are not up to the CDM Standard. However, if waste incineration is carried out using the invention's waste incinerator, and because the carbon-content in the slag is less than or equal to 1%, which is in compliance with the CDM Standard, the project can register to become a CDM project.

(3) Total waste combustion.

No fresh air is drawn into the third combustion chamber. Only the residual combustion air that enters into the chamber is utilized to burn the rubbish waste completely.

CLAIMS

(1) A honeycomb grate incinerator, which includes a furnace jacket, its novelty: a lining (30) lining (30) and honeycomb grates (20) are laid in the said furnace jacket (10); the said honeycomb grate (20) is a grate with a hollow passage (21), the outer end of each honeycomb grate (20) is in contact with the inner surface of the furnace jacket (10), and the inner end of each honeycomb grate has several gas outlets (22) connecting the hollow passage (21) to a furnace chamber (12); the said hollow passage (21) is also connected with the gas inlets (11) in the furnace jacket (10).

(2) According to claim 1 of the said honeycomb grate incinerator, its novelty: the said honeycomb grate (20) is composed of several grate bricks (20A), there is an air passageway (21A) in the said grate brick (20A), there are gas outlets (22A) on the inner end of the grate brick (20A) which are connected to the said air passageway (21A), the outer end of each of the said grate brick (20A) are laid along the axial interior of the furnace jacket (10), forming the honeycomb grate (20) with a hollow passage and gas outlets.

(3) According to claim 2 of the said honeycomb grate incinerator, its novelty: the said grate brick comprises two grate units (20B)

(4) According to claim 1 of the said honeycomb grate incinerator, its novelty: on the outer surfaces of the honeycomb grate (20) and the lining (30), there are ventilation grooves (31) connecting to the gas inlets (11); each of the said ventilation groove (31) is also directly connected to the hollow passage (21) of the honeycomb grate (20).

(5) According to any of the claims 1 to 4 of the said honeycomb grate incinerator, its novelty: there are several combustion chambers in the furnace chamber (12) of the furnace jacket (10) of the said incinerator.

(6) According to claim 5 of the said honeycomb grate incinerator, its novelty: in the furnace chamber (12) of the said incinerator, there is a first combustion chamber (12A), a second combustion chamber (12B) and a third combustion chamber (12C); there are said honeycomb grates (20) in the first combustion chamber (12A) and the second combustion chamber (12B); there are ventilation grooves (31) on the outer surface of the honeycomb grates (20) and lining (30) found at the gas inlets (11) of the furnace jacket (10); the said ventilation groove (31) is connected to the hollow passage (21) and gas inlet (11); the hollow channel (21) between the first combustion chamber (12A) and second combustion chamber (12B) is separated.

(7) According to claim 6 of the said honeycomb grate incinerator, its novelty: the axis of the said incinerator makes an inclined angle with the horizontal, and the sine value of the angle ranges from 0.03 to 0.04.

(8) According to claim 1 of the said honeycomb grate incinerator, its novelty: there is a nozzle spout for spray-injecting pulverized lime at the front end of the said incinerator.