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(54) **METHOD OF AND CHARGE FOR CLEANING INCINERATOR HEAT EXCHANGERS**

(57) Method of cleaning a furnace heat exchanger and/or a flue gas heat exchanger in a boiler of an incinerator, the heat exchanger comprising bundles of tubes or a membrane wall formed by or containing tubes, the method comprising the steps of attaching a pyrotechical charge to the end of a lance, inserting the charge into the incinerator, positioning the pyrotechical charge in an ally between bundles or between the tubes in a bundle, and initiating deflagration thus removing deposits, such as slag, from the tubes.

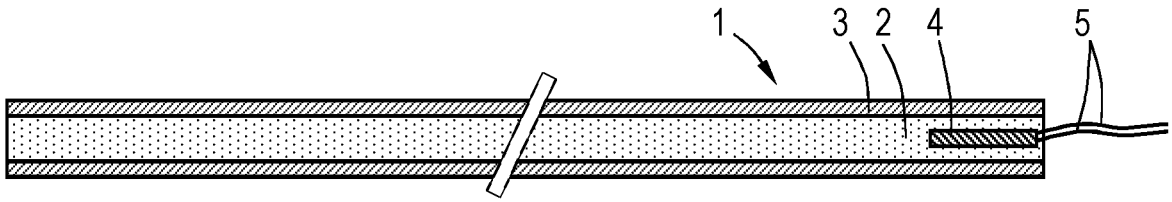

Fig.1

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Description

[0001] The invention relates to a method of and a charge for on- or offline cleaning cleaning a furnace heat exchanger and/or a flue gas heat exchanger in a boiler of an incinerator, the heat exchanger comprising bundles of tubes or a membrane wall formed by or containing tubes.

[0002] EP 2 383 534 discloses a method for cleaning contaminations from heat exchangers, waste-heat boilers or combustion chambers, wherein the contaminations are loosened and/or removed by a linear blasting between the tubes to be cleaned. A pipe is provided inside with a blasting cord, is flowed through by a coolant, is brought between the tubes to be cleaned, the blast is triggered, and the pipe is destroyed upon the blast.

[0003] It is an object of the present invention to provide an improved method of and a charge for cleaning incinerator heat exchangers.

[0004] To this end, the method according to the present invention comprises the steps of attaching a pyrotechnical charge to the end of a lance, inserting the charge into the incinerator, e.g. through a manhole or inspection port, positioning, by means of the lance, the pyrotechnical charge in an ally between bundles or between the tubes in a bundle, and initiating deflagration thus removing deposits, such as slag, from the tubes.

[0005] In an embodiment, the charge is elongated to cause a linear deflagration.

[0006] The invention also relates to a pyrotechnical charge for use in the method according to the present invention, comprising a detonator, such as an electrical detonator, for initiating deflagration of the charge.

[0007] In an embodiment, the charge has a length of at least 1 meter, preferably a length in a range from 1 to 3 meters, and/or a diameter smaller than 5 centimeters, preferably in a range from 1 to 4,5 centimeters, preferably in a range from 1,5 to 4 centimeters.

[0008] In another embodiment, the charge contains a pyrotechnical mixture and an explosive material.

[0009] In an example, the explosive material has been mixed with the pyrotechnical material, preferably homogeneously.

[0010] In another example, the explosive material is shaped as an elongated body extending through or along the pyrotechnical material. In a refinement, the elongated body extends through the center of pyrotechnical material and thus coincides with the centerline of the elongated charge.

[0011] By combining a pyrotechnical mixture and an explosive material, the force (energy) of the charge can be adjusted, e.g. to provide a charge that will effectively remove deposits from heat exchanger tubes, without causing damage to the heat exchanger tubes.

[0012] In an embodiment, the explosive material is coated or is surrounded, preferably by a tube, sleeve or sheath. Thus, it is isolated or at least separated from the pyrotechnical mixture.

[0013] In another embodiment, the charge comprises a casing, such as a tube or tight wrapping.

[0014] In a refinement, the casing is made from a non-metallic material. In another refinement, the casing is made from a synthetic material, such as a thermoplastic polymer, or a cellulose-based material, such as paper.

[0015] In an embodiment, the detonator is accommodated in a housing, which housing is attached to the casing and movable between a first position, wherein the detonator is isolated from the charge, and a second position, wherein the charge is exposed to the detonator, e.g. wherein the detonator extends in the charge.

[0016] In an embodiment, the housing or detonator on the one hand and the casing on the other hand comprise engaging parts that enable moving, and preferably also locking after priming, of the detonator to inside the charge by relative sliding and/or rotation of the housing and the casing.

[0017] In a refinement, the housing or detonator on the one hand comprises at least one protrusion, such as a cam, key, or external screw thread, or a groove, such as an bayonet slot or an internal screw thread, and the casing on the other hand comprises a groove or protrusion, respectively, cooperating with the protrusion or groove in or on the housing to define a path of the relative movement.

[0018] Thus, the charge can be primed at the work, e.g. some moments prior to its use, by establishing e.g. a screw, bayonet, or snap fit connection between the detonator and the casing.

[0019] In an embodiment, to shield it from static electricity and/or moist, in the first position of the housing, the detonator is enclosed or encapsulated by a synthetic material, such as a thermoplastic polymer.

[0020] In an embodiment, the detonator is configured to initiate deflagration at a current of at least five Ampere, preferably at least ten Ampere, preferably at least twenty Ampere. By providing a detonator having a firing current of at least 5 A, the risk of accidental detonation resulting from sparks or static electricity, occurring e.g. during transport or at a work, is reduced.

[0021] In an embodiment, the casing is enveloped by a thermally insulating material and/or a liquid absorbing material. Thus, the charge is for, e.g. a few minutes, protected from heat and/or cooled by a coolant, such as water soaking the liquid absorbing material.

[0022] In an embodiment, the nett mass (NEM) of the charge is in a range from 20 to 1000 grams, preferably in a range from 20 to 500 grams.

[0023] The nett mass of the charge, the dimensions and shape of the charge, and ratio of the pyrotechnical mixture and the explosive material substantially determine the speed and energy of the deflagration and the size and shape of the shock wave.

[0024] In an embodiment, the pyrotechnical mixture is in accordance with class P2 of directive 2007/23/EC of the European Parliament and of the Council of 23 May 2007 on the placing on the market of pyrotechnic articles.

The mixture may for example comprise a reducing agent or fuel, such as black powder, aluminum, boron, titanium and/or magnesium; and an oxidant such as sodium nitrate, potassium chlorate and/or potassium perchlorate. Preferred examples of pyrotechnical mixtures include black powder, aluminum and potassium perchlorate.

[0025] In another embodiment, the explosive material comprises pentaerythritol tetranitrate - also known as PENT, PENTA, TEN, corpent, penthrite or nitropenta -, ammonium nitrate/fuel oil (anfo) and/or gelatinous explosive, such as ethylene glycol dinitrate, diethylene glycol dinitrate, nitro-glycerine.

[0026] In an embodiment, the weight percentage of the explosive material in the charge is in a range from 5 to 40 wt%, preferably in a range from 10 to 40 wt%, preferably in a range from 15 to 30 wt%.

[0027] In an embodiment, the detonator is a wireless detonator configured to initiated deflagration upon receiving an encrypted radio signal.

[0028] In another embodiment, the detonator is coupled to a controller by a set of wires, which controller is configured to continually measure electrical resistance of the wires and the detonator.

[0029] Thus, it is possible to continually monitor the condition of the system and reduce the risk of a misfire.

[0030] In an embodiment, the charge contains or is surrounded by an abrasive material, such as grit, to enhance the cleaning effect of the deflagration.

[0031] The invention also relates to a system for on- or offline cleaning comprising a charge as described above, a lance, which is provided at its proximal end, i.e. the end (to be) held by and thus close to an operator, a supply for a coolant, such as water or a mixture of air and water, and a connector and/or electrical wires to connect the detonator to a controller and which is provided at its distal end, i.e. the end far or farthest from the operator, with a head for holding the charge and provided with outlets, e.g. nozzles, or ducts for supplying coolant to or about the charge, when it is placed in the head.

[0032] In an example, the wires of the detonator are connected to the wires in the lance, the charge is primed and fixed in the head of the lance. Next, the coolant supply is turned on and the charge is inserted, by means of the lance, through an opening, such as a manhole, in an online incinerator, i.e. an incinerator at full or partial load, and positioned between the tubes of a bundle in a heat exchanger, to be cleaned. A spray or mist of coolant surrounds the charge to prevent it from untimely deflagration. When at the desired location, the detonator is activated and the charge deflagrates, thus cleaning the adjacent tubes.

[0033] In an embodiment, the lance has a length in a range from 3 to 8 meter, preferably a length in a range from 4 to 7 meter.

[0034] For the sake of completeness, attention is drawn to the following prior art.

[0035] WO 2011/096872 relates to a rock cracker cartridge (numeral 1 in the figures of WO 2011/096872) which contains a cracking powder charge (6) and an ignition capsule (30) with an ignition powder charge (29) in an ignition unit sleeve (31) which does not possess the mechanical strength that would be required for the ignition powder charge to be exploded in the open air when ignited. In the rock cracker cartridge there is also provided an ignition assembly sleeve (7a) which surrounds the ignition unit sleeve when the rock cracker cartridge is primed. In combination, the assembly which surrounds the cracking powder charge, and which comprises the ignition unit sleeve and the ignition assembly sleeve, has a sufficient strength for an adequate pressure to be developed in the assembly such that the ignition powder charge will explode and generate a flame of fire and the ignition unit sleeve as well as the ignition assembly sleeve be penetrated by the pressure and the flame of fire, said flame of fire igniting the cracking powder charge.

[0036] DE 20 2017 001549 relates to a system for deslagging containers and plants by means of blasting, wherein a classified as a so-called firecrackers / pyrotechnics, disintegrants (z. B. class IV, T1 or T2), in the vicinity of the pollution or Caking or slagging is brought, and the explosive mixture is made to explode.

[0037] EP 1 275 925 relates to a process and device for local destruction of compact material, e.g. clinker coating, masonry remains, etc., in hot thermal systems such as heat exchangers, industrial ovens, furnaces, and metallurgical melting vessels, which uses an explosive (numeral 5 in the Figures) arranged on the front end of a lance (3) in a cooling container (1) through which coolant (4) flows.

[0038] EP 1 067 349 relates to a device, system and method permitting online explosives-based cleaning and deslagging of a fuel burning facility (31) such as a boiler, furnace, incinerator, or scrubber. A coolant, such as ordinary water, is delivered to the explosives (101) to prevent them from detonating due to the heat of the online facility.

[0039] Handbuch Sprengtechnik, VEB Deutscher Verlag fur Grundstoffindustrie, Leipzig 1975, pages 344-351 discloses the cooling of explosive charges.

[0040] US 5,494,004 relates to an online pulsed detonation/deflagration soot blower.

[0041] The invention will now be explained in more detail with reference to the drawings, which show a preferred embodiment of the present invention.

Figure 1 is a cross-section of a charge wherein an explosive material has been mixed homogenously with pyrotechnical mixture.

Figure 2 is a cross-section of a charge with an elongated body of explosive material in a pyrotechnical mixture.

Figures 3 and 4 show the charges of Figures 1 and 2 surrounded with an abrasive material.

[0042] Figure 1 is a cross-section of an elongated

charge 1. The charge comprises a homogenous blend 2 of an explosive material, e.g. nitropenta, and a pyrotechnical mixture. The blend has been compacted and tightly wrapped in a paper casing 3. A high intensity detonator 4 has been inserted into the blend at one end of the charge 1. The detonator can be coupled to a controller by means of a set of wires 5.

[0043] Figure 2 is a cross-section of another elongated charge 1. The charge comprises a pyrotechnical mixture 6 and an explosive material 7, e.g. nitropenta. The explosive material is in the form of an elongated body and provided with a coating or contained in a thin-walled flexible tube (not shown). It extends through the center of the pyrotechnical mixture and coincides with the centerline of the elongated charge 1. The pyrotechnical material is enveloped by a casing, in this example a rigid plastic tube 8. A high intensity detonator 4 has been inserted into the pyrotechnical mixture 6 at one end of the charge 1.

[0044] Figures 3 and 4 show the charges of Figures 1 and 2 surrounded with an abrasive material, such as grit 9.

[0045] Combining a pyrotechnical mixture with an explosive material in a casing of a relatively soft material provides considerable advantages. The charge can be reliably initiated and fragmenting of the (relatively long and thin) charge before it is properly and completely ignited is prevented or at least reduced. Further, this combination provides deflagration that has sufficient force (energy) to remove deposits, such as slag, from heat exchanger tubes. Thus, the abrasive effect of shrapnel from e.g. a metal tube is not required and the risk of damaging the tubes is further reduced.

[0046] The invention is not restricted to the above-described embodiments, which can be varied in a number of ways within the scope of the claims.

Claims

1. Method of cleaning a furnace heat exchanger and/or a flue gas heat exchanger in a boiler of an incinerator, the heat exchanger comprising bundles of tubes or a membrane wall formed by or containing tubes, the method comprising the steps of
   attaching a pyrotechical charge to the end of a lance, inserting the charge into the incinerator,
   positioning the pyrotechical charge in an ally between bundles or between the tubes in a bundle, and initiating deflagration thus removing deposits, such as slag, from the tubes.

2. Method according to claim 1, wherein the charge is elongated to cause a linear deflagration.

3. Pyrotechical charge for use in the method according to claim 1 or 2, comprising a detonator, such as an electrical detonator, for initiating deflagration of the charge.

4. Method or charge according to any one of the preceding claim, wherein the charge has a length of at least 1 meter and/or a diameter smaller than 5 centimeters, preferably in a range from 1 to 4,5 centimeters, preferably in a range from 1,5 to 4 centimeters.

5. Method or charge according to any one of the preceding claims, wherein the charge contains a pyrotechnical mixture and an explosive material.

6. Method or charge according to claim 5, wherein the explosive material has been mixed with the pyrotechnical material, preferably homogeneously.

7. Method or charge according to claim 5, wherein the explosive material is shaped as an elongated body extending through or along the pyrotechnical material.

8. Method or charge according to claim 7, wherein the explosive material is coated or surrounded, preferably by a tube, sleeve or sheath.

9. Method or charge according to any one of the preceding claims, wherein the charge comprises a casing, such as a tube or tight wrapping.

10. Method or charge according to claim 9, wherein the casing is made from a non-metallic material.

11. Method or charge according to claim 9 or 10, wherein the casing is made from a synthetic material, such as a thermoplastic polymer, or a cellulose-based material, such as paper.

12. Method or charge according to any one of the preceding claims, wherein the detonator is accommodated in a housing, which housing is attached to the casing and movable between a first position, wherein the detonator is isolated from the charge, and a second position, wherein the charge is exposed to the the detonator.

13. Method or charge according to any one of the preceding claims, wherein the detonator is configured to initiate deflagration at a current of at least five Ampere, preferably at least ten Ampere, preferably at least twenty Ampere.

14. Method or charge according to any one of the preceding claims, wherein the casing is enveloped by a thermally insulating material and/or a liquid absorbing material.

15. Method or charge according to any one of the preceding claims, wherein the pyrotechnical mixture

comprises a reducing agent or fuel, such as black powder, aluminum, boron, titanium and/or magnesium, and an oxidant such as sodium nitrate, potassium chlorate and/or potassium perchlorate and/or wherein the explosive material comprises pentaerythritol tetranitrate, ammonium nitrate/fuel oil (anfo) and/or gelatinous explosive.

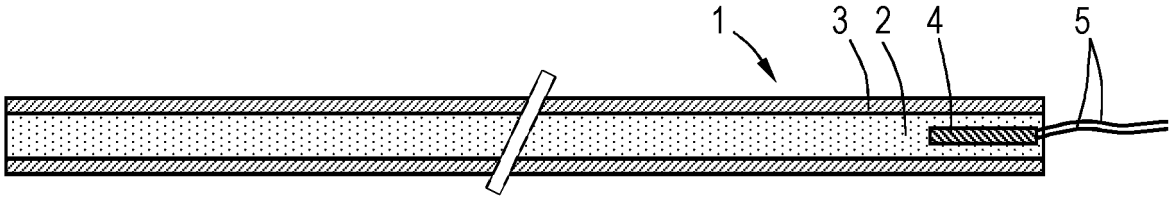

Fig.1

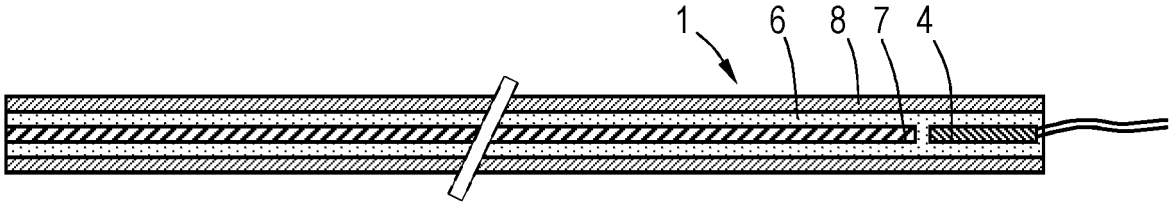

Fig.2

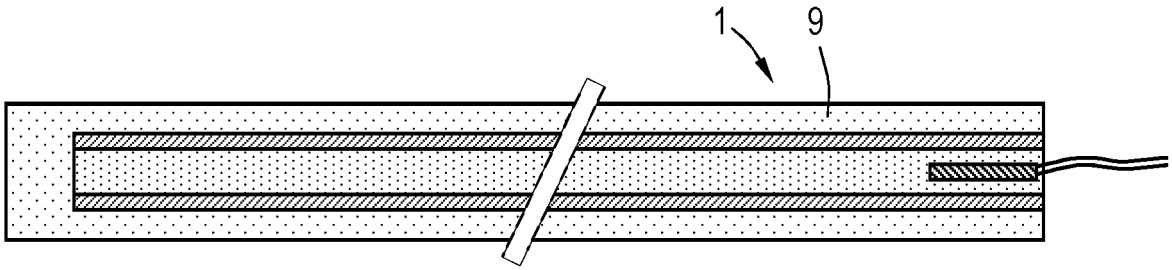

Fig.3

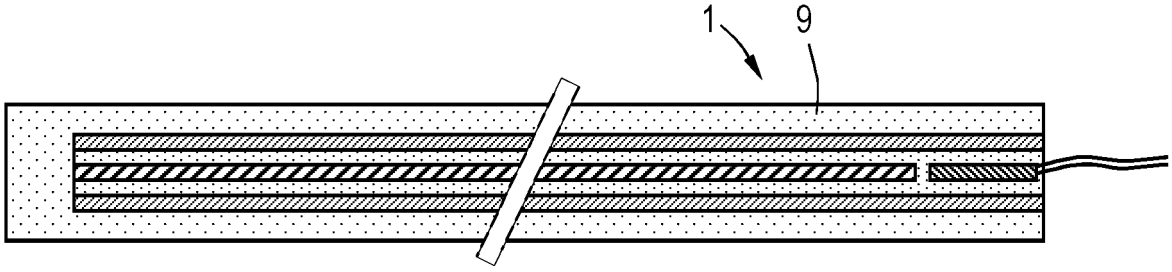

Fig.4

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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 6099

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	DE 20 2017 001549 U1 (KRUSE VOLKER [DE]) 28 June 2018 (2018-06-28)	1-6, 9-11, 13-15	INV. F27D25/00 B08B7/00 F28G7/00
A	* paragraphs [0001] - [0045] *	7,8,12	
X	US 2006/124019 A1 (COUGHLIN JOHN F [US] ET AL) 15 June 2006 (2006-06-15)	3-6, 9-11, 13-15	
A	* paragraphs [0012] - [0022]; figures 1, 2 *	7,8,12	

TECHNICAL FIELDS SEARCHED (IPC)

B08B
F27D
F28G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 September 2020	Kasten, Klaus

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 16 6099

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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29-09-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 202017001549 U1	28-06-2018	NONE	
US 2006124019 A1	15-06-2006	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- WO 2011096872 A **[0035]**
- DE 202017001549 **[0036]**
- EP 1275925 A **[0037]**
- EP 1067349 A **[0038]**
- US 5494004 A **[0040]**

Non-patent literature cited in the description

- VEB Deutscher Verlag fur Grundstoffindustrie. Handbuch Sprengtechnik. 1975, 344-351 **[0039]**