

METHOD AND DEVICE FOR CLEANING COMBUSTION INSTALLATIONS

The invention relates to a method and to a device for cleaning vessels contaminated with dirt, resp. with slag or ashes. In particular it is related to a method and to a device for the so-called on-line blast cleaning of combustion installations in accordance with the preamble of the independent claims.

- 5 Heating surfaces, e.g. of waste incineration plants or of coal fired boilers in general are subject to a strong contamination with dirt. These types of dirt normally have inorganic compositions and are typically produced by deposits of ash particles on the walls. Areas in the zone of high flue gas temperatures are in most instances very hard, because they remain stuck to the walls either in molten form or melted on form
10 or else are stuck together on the wall by substances melting or condensing at lower temperatures, when these solidify on the colder boiler wall. Coatings of this kind can only be removed with difficulty and unsatisfactorily by known cleaning methods. This leads to the consequence, that the boiler has to be switched off periodically, cooled down and cleaned either manually or by means of sand-blasting. Because
15 boilers of this kind in most instances have very large dimensions, it is frequently necessary to install a scaffolding in the furnace for this purpose. This additionally necessitates an interruption of the operation lasting several days or weeks and apart from this, because of the substantial dust – and dirt emissions it is exceedingly unpleasant and unhealthy for the cleaning personnel. A usually unavoidable accompa-

nying phenomenon of the interrupted operation of an installation are damages to the vessel materials themselves as a consequence of the great temperature changes. Apart from the cleaning – and repair costs, the stand-still costs of the installation due to the production - resp. income losses represent an important overall cost factor.

- 5 Conventional cleaning methods, for example, are boiler beating and the utilisation of steam-jet cleaners, water-jet blowers / soot blowers and shot peening.

Known is a cleaning method, in the case of which the cooled down - and also the hot boiler still in operation is cleaned by means of the introduction and igniting of explosive devices. In the case of the method described in the document EP 1 067 349, a
10 cooled explosive device by means of a cooled lance is brought into the proximity of the heating surface contaminated with dirt, where the explosive device is then ignited. The cakings on the heating surfaces are blasted off by force of the detonation, as well as by the vibrations of the wall produced by the shock waves. With this method, the cleaning time in comparison with the conventional cleaning methods is
15 able to be reduced significantly. With the necessary safety precautions, the cleaning can take place on-line, i.e., during the operation of the combustion furnace, resp. while the vessel is still in a hot condition. With this method, it is possible to clean a boiler within hours, while with a conventional cleaning method days would be required for this.

- 20 Disadvantageous in the case of the method described in EP 1 067 349 is the necessity of explosives. Apart from the high costs of the explosive material, in order to avoid accidents, for example, during the storage of the explosive material, elaborate security precautions have to be undertaken. The introduction of explosive material into a hot vessel in addition calls for an absolutely reliable and efficient cooling system, in
25 order to prevent a premature detonation of the explosive material.

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Embodiments of the invention seek to create a method and a device for the cleaning of combustion installations or vessels contaminated with dirt, resp. with slag, with which the installation does not have to be shut-down during the cleaning operation, with which the installation is in a clean condition again in a short time and especially with which any endangering of personnel and of installation components during the cleaning process is minimised.

According to a first aspect of the invention, there is provided method for the cleaning of contamination with dirt, resp. caking or slag deposits in vessels and installations by means of blasting technology preferably during the operation of the installation, resp. when the vessel is hot, characterised in that a pipe-like device, resp. lance is brought into the vessel or installation in such a manner that the mouth of the pipe-like device, resp. lance is positioned in the proximity of the contamination with dirt, resp. caking or slag deposits, that a flowable, explosive mixture, or flowable components which components, when mixed, form an explosive mixture, are guided through the pipe-like device, resp. lance, thereby getting into the proximity of the contamination with dirt, resp. caking or slag deposits, and that the explosive flowable mixture, which is, when appropriate, produced by mixing of the flowable components, is made to detonate.

According to a second aspect of the invention, there is provided device for the cleaning of contamination with dirt, resp. caking or slag deposits in vessels and installations, characterised in that it comprises a lance designed in the manner of a pipe and comprises means of supply on one end of the lance, wherein the means of supply are designed in a manner in order to conduct into the lance either in one conduit or separately, a flowable explosive mixture or flowable components, which components, when mixed, form an explosive mixture, and that the lance on its other end, which end is to be introduced into the vessel, comprises an expandable thin-walled container.

Embodiments of the cleaning method disclosed here is based on bringing gaseous, liquid and/or powdery materials resp. components, which are either individually explosive or in preference only explosive as a mixture, into the proximity of an object to be cleaned, in order to subsequently get the at least partially gaseous explosive mixture to detonate.

For the protection of people, the materials should be able to be stored and handled separately, in order to if at all possible be able to exclude the hazard of a premature explosion. This is possible with the embodiments of the cleaning method in accordance with the invention, because the explosive material or the explosive mixture is capable of being produced at the point or in the vicinity of the point of a vessel, in which it is to be utilised. This enhances the safety for persons and objects. With the cleaning device according to embodiments of the invention, during an introduction - and positioning process of the device no explosive materials or components are present yet and therefore also not exposed to the prevailing heat.

The cleaning process in accordance with embodiments of the invention is particularly suitable for combustion installations with sticky, fly ash with a tendency to caking, which is produced especially by the combustion of coal, refuse, sewage sludge or hazardous

waste materials. This is applicable in particular in the field of steam generators of combustion installations. The cleaning process, however, may also be applied for the removal of dirt in other installations with hard deposits of dirt, such as, e.g., in flue gas cleaning installations, paper mills, silos, in the cement industry, etc.. The blast
5 cleaning is able to be carried out during the operation of a plant, i.e., on-line or with the vessels still hot and exceedingly purposefully and precisely dosed. As a result, the plant down-time costs are reduced and no components of the installation or sections of the vessel are unnecessarily subjected to any load. The hazards for the personnel of the plant are also minimised. This in particular as a result of the exceedingly short dwell time of the at least partially gaseous explosive components or of the
10 mixture in the hot ambient.

In a preferred embodiment of the cleaning method according to the invention, a fuel, in liquid or gaseous form, e.g. acetylene, ethylene, methane, ethane, propane, petrol (gasoline), oil, etc. and an oxidising agent, e.g., oxygen, are brought into the proxim-
15 ity of a surface to be cleaned. There the components are mixed together and subsequently ignited. The force of the detonation and the surface made to vibrate by the shock waves, e.g. a wall of a vessel or of a pipe, cause the breaking off of the cakings on the walls and with this the cleaning of the surface. The components can also be mixed together in the device according to the invention.

20 The force of the explosion necessary for cleaning and with this the quantity of the materials used is dependent on the type of contamination with dirt and on the size of the dirty vessel. The dosing and the force of the explosion are able to be and are selected in such a manner, that no damage to the installation occurs. For example, the mixed gas quantity of acetylene and oxygen necessary for an effective cleaning lies
25 between 5 and 30 litres per explosion. The optimum mixing ratio of the gases can be calculated from the stoichiometry of the gases and in the case of acetylene and oxygen it amounts to 1:3. In the case of an explosive gas mixture of oxygen and acety-

lene, the ratio is at 3.5:1 with a total gas volume of , for example, approx. 100 litres. The possibility of the optimum dosing of the components utilised on the one hand reduces the cleaning costs and on the other hand also reduces the hazard – and damage risk for the installation and for human beings.

- 5 An in preference pipe-like device, e.g. a lance, is introduced into an installation resp. into a vessel and brought into the proximity of the place to be cleaned. By means of this device, after the positioning of the device the component or the components are able to be introduced into the installation resp. into the vessel. In the case of an on-line cleaning operation, the vessel to be cleaned and, e.g. the flue gas may be up to
10 1000°C hot. This signifies, that for the prevention of a premature explosion the materials utilised for cleaning, e.g. gases and fuels, should be brought to the desired place more rapidly than they are capable of being heated up by, e.g. heat radiation. The pipe is in preference thermally insulated and/or cooled. This can be achieved by a pipe made out of thermally insulating materials resp. by a cooling system attached to
15 the pipe or conducted through the pipe. The cooling for a pipe and/or for the materials utilised for the cleaning is preferably designed in such a manner, that it is capable of functioning without a continuous supply of coolant from outside into the cleaning device or to the components or to the explosive mixture of gas, respectively. A pipe or a lance therefore would only have to be equipped with the connections for the, for
20 example, gaseous components and correspondingly could be designed to be more simple. A cleaning device of this type is also not dependent on, e.g. water connections in the vicinity of the object to be cleaned. If for the cooling a coolant, such as, for example, water is utilised as insulation material for the lance, then for this purpose connections have to be attached to the lance. Any hoses required could, if so
25 desired, be removed prior to the actual utilisation of the lance for the cleaning operation. If a cooling of the lance in a positioned condition by means of a flow of coolant is necessary, then this in preference is effected by conducting a coolant through the lance, so that it flows directly into the hot vessel. A cleaning device, however, may also be designed in such a manner, that a coolant flows back again inside the device.

In order to completely preclude the possibility of a premature explosion, the explosive, at least partially gaseous mixture is preferably only produced at the point, where the explosion is to take place. This is implemented, for example, by mixing a combustible gas and an oxidising agent in the vessel itself, which is to be cleaned. It is, however, also possible to already bring together the individual components in a part of a supply line, e.g., inside the lance. As a result of this, the thorough mixing of individual components is already started shortly before the place to be cleaned. With the necessary safety precautions, it is also possible to directly introduce an explosive gas or gas mixture into an installation resp. into a vessel. Also in the case of this variant, the hazard of a premature explosion of explosive materials or mixtures is minimal, because the introduction of a device and a possibly required positioning of it is able to be carried out beforehand and therefore completely without the presence of any explosive materials. If instead of gaseous materials one or more materials in liquid or powder form, e.g. fuels, are utilised, then these are conducted to the place to be cleaned through e.g. the pipe-like device by means of a suitable pumping device, where the material or materials in liquid or powder form is, resp. are, in preference nebulised or atomised. This can be implemented, for example, by a pressure – or gas atomisation, e.g. by using a gas utilised in the cleaning operation.

The dosing of gases, resp. of gas mixtures, possibly also of liquid materials, takes place preferably by means of pressure vessels. Beforehand, precisely dosed quantities of gas resp. liquid can be introduced into these pressure vessels, e.g. by means of controlled filling from commercially available gas cylinders. The utilisation of separate pressure vessels provides the benefit, that the quantities and with this the fill pressures in these vessels are capable of being adapted to the desired force of the explosion in a very simple manner. In addition, by the introduction of the gases or liquids under pressure, the dwell time of the components in the hot ambient is able to be kept exceedingly short.

In order to prevent a dilution of gases, gas mixtures, materials in powder or liquid form, e.g. by the ambient air or flue gas, the materials are preferably held at or in the proximity of the place to be cleaned, for example, by means of a suitable thin-walled container. This is particularly advantageous in such cases, where an explosive mixture is to be produced only in the proximity of the surface to be cleaned, for example, by a separate conducting of individual gases or fuels in a pipe-like device or a lance, resp.. A vessel of this kind, i.a., serves for preventing a dilution of the gases, in particular prior to their complete mixing and if so required also serves for their cooling. Examples of suitable thin-walled containers are expanding, thin-walled, balloon-like containers, or flexible, elastic, thin-walled containers, such as, for example, sack-like envelopes or sacks. A thin-walled container is preferably attached to one end of a pipe, e.g., at the front end of the lance and is inflated by the gases themselves. In order to prevent a premature explosion of the thin-walled container, it should be inflated more rapidly than it heats up as a result of convection or radiation and/or it should be cooled. In preference, the thin-walled containers have a greater volume than the total volume of the components introduced into them. On the one hand, this prevents a premature destruction of the thin-walled container by bursting, e.g. of elastic, balloon-like container. On the other hand, for example, in the case of containers made out of non-expanding materials, such as, for example, sack-like plastic or paper envelopes, there is no overpressure in the container relative to the ambient. This prevents or minimises any outflow of gas in the case of permeable materials or in the case of a possible perforation of the thin-walled container, which could be caused, for example, by sparks or by sharp objects.

A front end cooling of the lance resp. the cooling of a thin-walled container is implemented in preference by means of passive cooling methods. In the case of a passive cooling of an explosive gas mixture, in the introduced condition of the cleaning device no additional cooling means are brought in from the outside to or into the explosive mixture. Apart from general constructional simplifications of the cleaning device this also has the advantage that supply lines for the materials required for the

explosion can relatively easily be kept separate from a possible lance cooling system. In the case of a combination with a passive lance cooling system, the complete cleaning process is able to be kept essentially independent of a locally available infrastructure.

- 5 A thin-walled container, and therefore also the materials contained in it, is capable of being protected against undesirably high heating-up by means of a thermal insulating protective envelope or by means of a protective envelope already containing a coolant. An example for the latter kind of protective envelope can be designed in a very simple manner and, for example, would comprise a material as absorbent as possible,
10 e.g. crepe or a sponge-like material, which prior to being introduced into the hot installation is soaked with coolant, in preference water. It is, however, also possible to manufacture the thin-walled container itself out of a material, which absorbs or stores coolant.

- It goes without saying, that it is also possible to cool the thin-walled container by
15 means of a suitable coolant, e.g. by spraying water, air or a mixture of both media onto the thin-walled container. Also possible is the injection of water droplets or of a different coolant into the thin-walled container during its inflation, so that its surface is cooled from the inside. This, for example, can be combined with the introduction of a liquid or gaseous component utilised for the cleaning operation.

- 20 A further preferred possibility of protecting the thin-walled container consists of introducing the thin-walled container into the vessel to be cleaned inside a suitable protective device. This is implemented, for example, by means of a protective device attached to the cleaning device, e.g. a protective bell or funnel attached to and around the lance. The thin-walled container can be stored in the protective device in unin-
25 flated condition. The protective device is designed in such a manner, that it provides

the thin-walled container with the possibility of a substantially free expansion as soon as it is inflated. This can e.g. be realised by an opened protective device or by one which opens by a force or by pressure, resp.. An opening of the protective device arranged on the container side, i.e. the front end of the lance, may be equipped with a
5 cover. A cover of this kind in preference is thin-walled, easy to open, resp., to release, so that it can be separated from the protective device by an expanding thin-walled container. A cover is preferably made out of materials, which are capable of being soaked with coolant, such as, e.g., a piece of paper, jute, etc.. Depending on the construction of a cover, the complete protective device can be enclosed by it. With
10 this, a thin-walled container as well as a protective device are simultaneously protected, e.g., cooled.

In a preferred embodiment, an indirect, passive cooling system is utilised both for the thin-walled container as well as for the lance, this for the reasons already mentioned above. A passive cooling for an explosive mixture and a lance is independent of
15 coolants actively brought in from the outside during the cleaning process itself, i.e., with the lance in the introduced condition. A passive lance cooling in preference takes place by the application of suitable materials around the pipe conducting gas and/or liquid, by manufacturing the pipe or the supply lines out of suitable materials. These, for example, are insulating, substantially heat-resistant materials or material
20 arrangements and/or materials capable of absorbing coolants. Examples for the latter kind are absorbent materials, such as paper, cotton-wool or fabrics, which prior to being used are soaked in water or another coolant. For the protection against damage to a cooling layer, external protective layers may be affixed. In the case of absorbent paper, this could be a simple bandaging with fabric. It is, however, also possible to
25 apply a more permanent protective layer made out of, for example, a metal screen or -webbing or a second metal pipe. Materials absorbing coolants are capable of releasing them again when required and as a result of the evaporation cooling produced are capable of cooling the pipe or the thin-walled container. Passive cooling systems may also be, for example, dense metal webs or ceramics, which are capable of ab-

sorbing coolant in hollow spaces or pores. It is also conceivable to construct a passive cooling system out of heat absorbing materials. Materials of this kind are in a position to absorb heat and to store it instead of conducting it onwards. Examples for this are materials, which within a suitably chosen temperature range are subject to a phase change, typically solid to liquid (so-called 'phase change materials' (PCM)). A further example for an insulating lance cooling system are double pipes, which may be filled with insulation material.

If so required, the most diverse cooling methods and protective devices may also be combined, made do without or complemented.

- 10 The ignition of the explosive gas mixture, resp., liquid - /gas mixture, with or without thin-walled container or protective envelope, resp., takes place with means known from prior art. In preference this is implemented by means of an electrically triggered spark ignition, by auxiliary flames or by a pyrotechnic ignition with the help of correspondingly attached ignition means and ignition devices. The means of ignition are preferably attached in the region of one of the ends of the lance, to a pipe itself or to the thin-walled container. The actuation of the ignition device as well as the sequence of an inflow of the gas and/or the introduction of liquid components in preference takes place by means of a control system.

20 The sequence of a blasting operation in a hot vessel in a preferred embodiment takes place as follows:

- Gas-pressure vessels by means of the actuation of corresponding valves are filled with the corresponding gases, e.g. acetylene or ethane and oxygen and the required gas quantities and – pressures out of pressure gas cylinders.

- At one end of a pipe a thin-walled container (for example, made of plastic material, a balloon- or sack-like envelope or a bag/sack) is attached, e.g. plugged on, clamped on or glued on with adhesive tape, and/or stowed in the protective device in folded condition.
- 5 - If so required, a head cooling is activated, e.g., a protective envelope (insulating and/or cooling) attached, resp., soaked with coolant and/or the cooling started together with the gas.
- The lance is introduced into the vessel to be cleaned from the outside, e.g. through an access opening, so that the end of the pipe including the thin-walled
10 container is placed in front of the surface to be cleaned.
- The opening of the valves of the gas pressure vessels starts the filling of the thin-walled container with the gas mixture.
- The ignition device is actuated and an explosion triggered.

15 Individual steps of the sequence mentioned above of a blast cleaning process in accordance with the invention may also be supplemented and/or automated with intermediate steps. For example, the triggering of an explosion process may be connected with safety mechanisms. These in preference start the gas supply from the pressure vessels to the thin-walled containers, or in general into the vessel to be cleaned and interrupt this connection before the actual explosion takes place, e.g., by means of an
20 activation of the means of ignition. This prevents, for example, blowbacks into the supply lines and uncontrolled detonations. In addition, the cleaning process may also include a device cleaning step. This is implemented, for example, by means of a

blowing-through with compressed air of the lance, resp., of individual pipes following the explosion.

In the following, embodiments of the device for the cleaning method for caked and slag contaminated vessels according to the invention are explained in more detail on the basis of exemplary and schematically drawn figures.

These illustrate:

Figure 1 a simplified depiction of an embodiment of the device in accordance with the invention,

Figure 2 a further embodiment of the device according to the invention,

10 Figure 3 a third embodiment of the device in accordance with the invention.

In Figure 1, a device 10 for carrying-out the cleaning process according to the invention is illustrated. The device 10 includes pipe-like supply lines 1, 2 through which, in preference after their positioning, different gases, e.g., oxygen 3 and ethane 4, but also liquid fuels or oxidising agents are conducted to the proximity of the wall 5 to be cleaned. The gases 3, 4 and/or liquids in the zone of the wall contamination with dirt 6 form an explosive mixture 7. By means of an ignition device 8, which is capable of being controlled and actuated from outside the vessel or installation to be cleaned, the explosive mixture 7, for example, by the generation of an ignition spark 9 is ignited. The explosion may also be triggered by an ignition device located in the zone of the gas mixture 7, e.g., on the supply lines 1, 2. The supply lines 1, 2 and the

ignition device 8, here are designed in such a manner, that the ignition spark 9 does not come to be situated directly in front of the end of a supply line 1, 2, in order to prevent a blowback of the cleaning device 10, resp., a backfire into the supply lines 1,2. This can be implemented, in that the ignition spark 9 comes to be situated in the
5 zone between the ends of supply lines 1, 2 of differing lengths.

The supply lines 1, 2 and the ignition device 8 or parts of it may also be jointly accommodated in a pipe-like envelope, e.g., in a pipe. The device 10 is preferably also equipped with a cooling system. The cooling in preference takes place by means of evaporation of the coolant, which cools the supply lines 1, 2 or the possibly present
10 common envelope. An active cooling takes place, for example, by means of an air – and or water supply from outside in - and/or through the supply lines 1,2.

In case of a thin-walled container possibly present on the device 10 for the protection of the gases against dilution, a head cooling system for the lance is in preference constructed as a protective envelope soaked with coolant. The head cooling system
15 may also be designed as a coolant supply conducted right into the container. In this manner, the thin-walled container, resp., the gas – or gas/liquid mixture contained in the container is cooled. The materials utilised for the supply lines 1, 2 and/or for a common pipe in addition preferably possess thermal insulation characteristics, in order to protect the gas 3, 4 or the liquid contained in it against external thermal
20 influences by, e.g., flue gas.

In Figure 2 a further exemplary device for the implementation of the cleaning process in accordance with the invention is illustrated. A coolable, resp., insulated lance
20, comprising an envelope 21 and an inner pipe 22, at one of its ends comprises connections 23 for the gas supply. Also situated in the zone of this end of the lance
25 20 is a suitable means of ignition, e.g., a spark plug 19, with which an explosive gas

mixture is capable of being ignited, in preference electrically. The envelope 21 protects the lance 20 and the gas or gas mixture present inside it against being heated up. In preference it comprises absorbent material, e.g. paper, and in addition it may be equipped with a protective layer surrounding the absorbent material, e.g., an absorb-
5 ent fabric or a heat-reflecting foil-like envelope in preference equipped with openings. A possible protective layer, not illustrated in more detail here, substantially serves to prevent or to reduce the peeling-off, resp., damaging of the material of the envelope 21 serving as an absorbent or storage device for the coolant by external mechanical influences. A protective layer may also be equipped with additional ab-
10 sorbent or insulating characteristics.

Attached to the other end of the lance 20 there is a thin-walled container 25, here already inflated, and a protective bell 27. The thin-walled container 25 is attached to the inner pipe 22 in such a manner, that it is inflated by the gas or gas mixture flowing through the inner pipe. The thin-walled container comprises a substantially gas-
15 tight plastic envelope 25a, e.g., a plastic sack made out of polyethylene and a protective envelope 25b surrounding the plastic envelope 25a. The protective envelope 25b in preference is an envelope made out of absorbent paper, which is connected with the plastic envelope 25a, in preference glued to it. Prior to the utilisation of the lance 20, i.e. prior to the introduction of the lance 20 into an installation to be cleaned, the
20 paper envelope and the sheathing 21 of the lance 20 are covered with coolant, e.g. soaked with water. The thin-walled container 25 is stowed in the protective bell 27 in folded condition. On top of the protective bell preferably there is an additional cover soaked with coolant (not illustrated in detail), in order to additionally cool the thin-walled container inside and if necessary to protect it from mechanical influences.
25 Following the introduction and positioning of the lance into resp. in the vessel to be cleaned, the thin-walled container 25 upon inflation leaves the protective bell 27. In doing so, it is protected from the heat of the flue gases by the water-soaked paper envelope and the inner pipe 22 by the sheathing 21. The protective bell 27 has a slightly conical shape opening outwards like a beaker, in order to give the inflated

envelope or the balloon-like container sufficient space. A protective device, for example, has the shape of a hollow cone or hollow cylinder or else of a bowl. In preference it comprises an opening located on one side for the passage of the supply line or lines and on the other side an opening for a thin-walled container. A protective device may also be constructed with double walls, so that a possible internal space is filled, resp. is able to be filled with insulating material or coolant. The protective bell 27, the sheathing 21 or another protective device are permanently attached to the lance. They may, however, also be constructed in such a manner, that they are able to be slid over the lance or laid around it and positioned in different ways. This if so required makes possible an easy replacement of a protective device following a cleaning process. For technical and economical considerations, however, for protective devices if at all possible heat-resistant materials are utilised.

The connection for the gas supply 23 is affixed to the inner pipe 22 and connects two gas supply lines 29, 30 with the lance 20. One of the gas supply lines 30 is connected with a first pressure vessel 34 through a solenoid valve 32, wherein this vessel itself is connected with a commercially available first gas cylinder 36 through a fourth valve 38, e.g., an oxygen cylinder. The second gas supply line 29 in essence is constructed in the same manner, i.e. it is connected with a second pressure vessel 33 through a second solenoid valve 33. This vessel in turn is connected with a second commercially available gas cylinder 35 through a third valve 37. The second gas cylinder 35 correspondingly contains a combustible gas, such as, for example, acetylene, ethylene or ethane.

After opening the third and fourth valves 37, 38, the pressure vessels 33, 34 are filled with the corresponding gases. A fill pressure already proved by trials lies at max. 15 bar, wherein the pressure vessel volumes, for example, have values of 1.5 l for ethane and 5 l for oxygen and typically an overall gas volume of 100 l - 200 l is utilised for the cleaning of customary vessels. The ratio of the volumes of both the pressure

vessels in preference corresponds to the stoichiometric ratio of the two gases for a complete combustion. The pressures of the gases in the pressure vessels determine the power of the explosion and are able to be adjusted through reducing valves on the gas cylinders 35, 36. These pressures are preferably the same.

5 By means of an external pressure switch 39 connected with the spark plug 19 on the lance 20, the detonation process is started. The sequence in preference is controlled with a control system 40, e.g. a relay control system. The control paths are indicated in the Figure as dashed lines, wherein the signal direction is indicated with arrows. First of all the solenoid valves are briefly opened, e.g. for a few seconds. During this
10 time period the gas content of the pressure vessels 33, 34 flows into the lance 20 through separate gas supply lines 29, 30. There the components are mixed and conducted into the thin-walled container 25 through the inner pipe 22, wherein they inflate it. In a preferred embodiment of the cleaning device, the gas supply lines 29, 30 are maintained separate in the inner pipe 22 of the lance, so that the gases are only
15 mixed inside the thin-walled container 25 and there form an explosive gas mixture.

After the closing of the solenoid valves 31, 32, in preference after a selected time delay of, e.g. 0.5 sec, the ignition device is actuated and the explosion is triggered. Depending on the selected construction of the gas supply, the spark plug 19 or the ignition device is correspondingly positioned on the lance. The inflation process of
20 the thin-walled container 25 amounts to a few seconds, typically 1 – 3 sec, e.g., 2 sec.

Following the ignition of the gas mixture, the inner pipe is preferably cleaned of the residues of the explosion, e.g. slag. This takes place, for example, by means of compressed air, which is sent through the inner pipe 22. For this purpose, one of the gas
25 supply lines 30 is equipped with an additional valve 41, which is connected with a

compressed air reservoir 42, e.g. a compressed air compressor or a compressed air cylinder. This additional valve 41, here depicted as a solenoid valve, preferably is also capable of being driven and actuated automatically.

5 If for the cleaning not only gaseous, but also, resp. exclusively liquid materials are utilised, then the volume of the thin-walled container 25 may be kept correspondingly small. It is then made out of a correspondingly suitable material, e.g. out of substantially liquid-tight plastic envelopes.

Figure 3 illustrates a third embodiment of the device in accordance with the invention. It comprises an exemplary construction of a coolable lance 50. A majority of
10 the reference marks are the same as in Figure 2. These correspondingly refer to the same exemplary characteristics and elements and not all of them are mentioned any-more at this point. The coolable lance 50 comprising an outer pipe 51 and an inner pipe 52, at its end is equipped with connections 23, 24 for the gas supply, as well as for the cooling. A coolant, e.g. an air-water mixture, is conducted between the outer
15 51 - and inner pipe 52. It exits at the end of the lance 50, which is indicated by arrows. At this second end of the lance 50, once again a protective bell 27 for the thin-walled container 25 is attached. Depending on the flow speed or the distance of the coolant outlet opening of the lance 50 from the protective bell 27, resp., the coolant conducted through the lance 50 is also able to cool the protective bell 27.

20 The connection 24 of the cooling system is equipped with a cooling connection valve 28, e.g. a manually operated valve. Actuating it enables switching on and - off the cooling system as required. In preference also the production of a certain mixing ratio of differing coolants is made possible, here represented by two connection lines or - hoses 24a, b, respectively.

A lance cooling system designed in this manner is in preference activated prior to the introduction of the lance 50 into a hot vessel. Typically it remains switched on for the whole time period, during which the lance is subjected to the heat. An active lance cooling system of this kind is also capable of being included in a control system 40. Naturally it is also possible to introduce a coolant through a coolant connection at one end of the lance 50 and to have it flow back again to the same end. This would be possible, e.g. in the case of an outer pipe 51 closed at one end with a substantially U-shaped or concentric coolant supply system.

The cleaning method according to the invention with the device described in Figure 3 proceeds in a similar manner as that of Figure 2: Soaking of a thin-walled container 25 with coolant, activation of the lance cooling system, introduction and positioning of the lance, filling of the pressure vessels 33, 34 with the required gas quantities, triggering of the ignition process by means of actuating a pressure switch 39. The gas, resp. the gases flow through the lance 50 and inflate the thin-walled container 25. This container is initially protected against heating up by the protective bell 27, thereupon substantially by the soaked protective envelope 25b. When the required gas volume has reached the thin-walled container 25, the explosive gas mixture is ignited by means of suitable means of ignition 19. In preference, following the carrying out of the cleaning process, the inner pipe 52 and possibly also the outer pipe 51 is cleaned in a cleaning step, e.g. by means of compressed air it is freed of slag and water.

The utilisation of a thin-walled container in accordance with the invention presented here provides the advantage, that it is exceedingly cheap to manufacture. An additional advantage of a thin-walled container made of a plastic sack enveloped with paper is the fact, that while any possible sparking can perforate the plastic sack, the envelope, however, continues to protect the explosive gas or - gas mixture. A protective envelope made of absorbent material may be constructed with several layers. By

means of the, for example, provision of several single-layer protective envelopes, the container therefore is capable of being adapted to temperatures in differently hot vessels. By exploiting the evaporation cooling of suitable coolants, no supply of coolant into or through the lance, resp., is necessary during the actual cleaning process.

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AMENDED CLAIMS

1. Method for the cleaning of contamination with dirt, resp. caking or slag deposits in vessels and installations by means of blasting technology preferably during the operation of the installation, resp. when the vessel is hot, **characterised**
5 **in** that a pipe-like device, resp. lance (20) is brought into the vessel or installation in such a manner that the mouth of the pipe-like device, resp. lance (20) is positioned in the proximity of the contamination with dirt, resp. caking or slag deposits (6), that a flowable, explosive mixture (7), or flowable components which components, when mixed, form an explosive mixture, are guided
10 through the pipe-like device, resp. lance (20), thereby getting into the proximity of the contamination with dirt, resp. caking or slag deposits (6), and that the explosive flowable mixture (7), which is, when appropriate, produced by mixing of the flowable components, is made to detonate.
2. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to claim 1, **characterised in** that the explosive, flowable mixture
15 or the flowable components are at least partly in a gaseous, liquid or powdery form.
3. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to claim 1 or 2, **characterised in** that a thin-walled container (25)
20 that is attached to the pipe-like device, resp. lance (20) is brought into the proximity of the contamination with dirt, resp. caking or slag deposits (6) by means of the pipe-like device, resp. lance (20), and that the flowable explosive

mixture (7) or the flowable components which components, when mixed, form an explosive mixture, is/are brought into the thin-walled container (35) and is/are made to detonate.

- 5 4. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to claim 3, **characterised in** that the thin-walled container (25) is inflated by gases (3, 4) or by the explosive flowable mixture (7) before detonation.
- 10 5. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to one of the claims 1, resp. 3 or 4, **characterised in** that the flowable, explosive mixture (7) is mixed in the proximity of a surface to be cleaned (5), resp. in the thin-walled container (25).
- 15 6. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to one of the preceding claims, **characterised in** that gases (3, 4) or the explosive, flowable mixture (7) flow out of at least one pressure vessel (33, 34) into the pipe-like device, resp. the lance (20).
7. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to one of the preceding claims, **characterised in** that the flowable explosive mixture (7) is produced by the mixing of a gaseous fuel (4) and a gaseous oxidising agent (3).
- 20 8. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to one of the claims 3-7, **characterised in** that as thin-walled

container (25) an inflatable envelope, such as, for example, a flexible plastic envelope (25a) or an elastic, balloon-like container is utilised.

- 5 9. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to one of the claims 2-8, **characterised in** that the pipe-like device, resp. the lance (20) and/or the thin-walled container (25) is cooled.
- 10 10. Method for the cleaning of contamination with dirt, resp. caking or slag deposits according to claim 9, **characterised in** that the thin-walled container (25) is cooled by a protective envelope (25b) soaked with coolant.
- 15 11. Device for the cleaning of contamination with dirt, resp. caking or slag deposits in vessels and installations, **characterised in** that it comprises a lance designed in the manner of a pipe and comprises means of supply (1,2) on one end of the lance, wherein the means of supply are designed in a manner in order to conduct into the lance either in one conduit or separately, a flowable explosive mixture (7) or flowable components, which components, when mixed, form an explosive mixture, and that the lance on its other end, which end is to be introduced into the vessel, comprises an expandable thin-walled container (25).
- 20 12. Device according to claim 11, **characterised in** that the means of supply are designed in a manner in order to conduct the flowable components separately through the lance.
13. Device according to one of the claims 11 or 12, **characterised in** that the thin-walled container (25) is an inflatable envelope, such as, for example, a flexible plastic envelope (25a) or an elastic, balloon-like container.

14. Device according to one of the claims 11 to 13, **characterised in** that it contains means of ignition (8) for the ignition of the explosive mixture (7) or for the components forming an explosive mixture (7).
- 5 15. Device according to one of the claims 11 to 14, **characterised in** that it comprises means for cooling the shaft of the lance and/or a head cooling system.
16. Device according to claim 15, **characterised in** that the head cooling system comprises a protective envelope (25b) soakable with coolant.
- 10 17. Device according to one of the claims 11 to 16, **characterised in** that the end of the pipe-like formed lance leading into the vessel comprises a protective device (27), in which the uninflated thin-walled container (25) is stowed away.