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(54) **PROCESS FOR THERMAL DESTRUCTION OF HAZARDOUS MATERIALS**

VERFAHREN ZUR THERMISCHEN ZERSETZUNG VON SCHADSTOFFEN

PROCEDE DE DESTRUCTION THERMIQUE DE MATIERES DANGEREUSES

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Description

FIELD OF INVENTION

[0001] The present invention refers to a process for eliminating hazardous materials, and more in particular regards a process for the thermal destruction of hazardous compounds, in particular of organic nature, for example, chlorinated compounds, such as PCBs, and materials polluted by such compounds. The invention moreover refers to a device that is deemed to be optimal for carrying out said process.

STATE OF THE ART

[0002] Industry uses, or produces as residue or by-products, compounds which are very harmful for the environment and for human health and which by now have accumulated in such large quantities that an adequate disposal thereof has become necessary.

[0003] Many of such substances are moreover particularly stable, so that it is not possible to rely on their spontaneous degradation to form harmless, or at least less dangerous, products; indeed, frequently their products of scission are also extremely harmful. This is the case with a large number of chlorinated organic compounds, which give rise to dioxin or similar molecules.

[0004] The storage of such substances in dumps that are purposely designed and protected is extremely costly and does not eliminate, but only shifts in time, the danger deriving from their introduction into the environment. Furthermore, even such specially designed dumps are subject to such calamities as floods and earthquakes, and/or are subject to possible trespassing and/or the setting-up of conditions that may prove aggressive for the containers of the stored substances.

[0005] It is therefore evident that storage is not a definitive and fully acceptable solution, and that it is necessary to devise other solutions, if possible definitive ones, among which particularly interesting ones are destruction or inertization by means of special processes.

[0006] In the field of chlorinated aromatic compounds, techniques of thermic destruction based on the use of special burners have been since now developed. Experience has, however, shown such techniques to lack validity, in that, due to the relatively low temperatures reached during combustion, the intermediate products of reaction recombine, giving rise to other products that are no less aggressive, such as dioxin.

[0007] For this reason, low-temperature electrochemical methods have been developed (typically of around 100-200°C), which transform the harmful products into residues presenting lower danger levels; these, however, must subsequently be sent on to special dumps. In addition, these methods are effective only when the pollutant is present in low concentrations, which, in the case of PCBs, must not exceed 30-40%.

[0008] It has therefore been proposed to use furnaces

employing plasma torches as heat source. The extremely high temperatures reached by plasma, i.e., over 5000°C, would ensure complete cracking of the pollutant into molecules which are very simple and cannot recombine to form particularly harmful products that are difficult to deal with.

[0009] US Patent 4.574.714 describes the use of a furnace containing a metal charge which is melted and brought to a desired temperature by any means, such as induction heating, electric arc, oxygen blowing and the like; the external source of heat is then turned off and the waste material introduced with oxygen below the surface of the molten bath. The high temperature of the bath (2500-4000 °F) dissociates the organic molecules and the carbon thus released is oxidised to CO and CO₂.

[0010] Such techniques, however, are slow in asserting themselves, basically because they do not guarantee that the pollutants are exposed to the high temperatures of the plasma for periods of time sufficiently long to ensure their complete destruction. In addition, plasma techniques are still somewhat costly, and the means necessary are delicate and difficult to maintain.

SUMMARY OF THE INVENTION

[0011] A purpose of present invention is thus to provide a reliable process for destroying hazardous compounds, in particular those of organic nature, such as chlorinated aromatic molecules, like PCBs.

[0012] Another purpose of this invention is also to guarantee that these pollutants, whether gaseous, liquid, or solid, will be completely eliminated even in concentrations of up to 100%.

[0013] Another purpose of the invention is to provide a simple and reliable device, operating with consolidated technologies, for putting the process into practice according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The process for the thermal destruction of hazardous materials according to the present invention is characterized in claim 1.

[0015] The ratio between the internal free volume of the furnace and the volume of the metal bath is preferably between 5:1 and 2:1. By "internal free volume inside of the furnace" is meant the internal volume of the furnace that is not occupied by the metal bath or by components such as electrodes, slag, and the like, i.e., the volume that is effectively available for the gases developed by combustion of the materials to be destroyed. A high value of this ratio allows said combustion gases to remain inside the furnace, subjected to the action of intense heating of the electric arc, of the metal bath and of the walls of the furnace itself, for a sufficiently long time to guarantee their reduction into innocuous or elementary gases. This time in which the gases remain in-

side the furnace is in excess of 3 seconds, and preferably over 6 seconds or, even more preferably, is between 8 and 15 seconds.

[0016] The furnace is obviously devised in such a way as to prevent any leakage of harmful gases; for example, it can be sealed, or preferably work in negative pressure. The material to be destroyed, which may be liquid, gaseous, or solid (in small-sized pieces), is directly fed into the area of the electric arc, where there exist plasma conditions or conditions that may be plasma-like, through an electrode having an axial hole in which there is inserted, in such a way as to be free to move, a special lance that can, if necessary, be cooled. Alternatively, if the material to be destroyed is in solid form, in pieces of sizes that are too large to be introduced through the electrode, it can be fed in the furnace, using special means of loading, directly into the molten bath.

[0017] It is preferable to create specifically in the electric arc area a true plasma by feeding in a suitable gas, for example nitrogen or argon, through an annular passage created between the internal walls of the electrode, provided with an axial hole, and the external walls of the lance that can move freely inside the electrode.

[0018] The combined action of the arc, the molten bath and the walls of the furnace guarantees both a particularly high treatment temperature and an exposure time that is amply sufficient, as mentioned above, for the complete dissociation of the materials to be treated according to the invention.

[0019] Preferably, inside the furnace an oxidizing atmosphere is generated by sending in air or oxygen to favour the transformation of the residue of combustion of the materials being treated into innocuous compounds or anyway compounds that may readily be treated using normal chemical means.

[0020] In the case where, due to the complexity or to the general characteristics of the molecules to be destroyed reasonable doubts could be raised with reference to adequacy of treatment times, it is possible to use means, such as the so-called foamed slags, which trap within them the gases developed by the thermal destruction of the materials being treated, slowing down their path towards the outlet from the furnace, and it is thus possible to increase the control over the necessary treatment for eliminating some of the outgoing materials, such as particulate, hydrochloric acid, and the like.

[0021] The device that allows the embodiment of the process according to the present invention is an ordinary electric-arc furnace, as used in steelmaking, suitably modified, by means of gas-tight sealing or operation in negative pressure, to prevent any gas leakage into the environment, and is characterized by the use of at least one electrode having an axial hole and carrying in said hole a cooled metal lance that is free to move axially for feeding in the material to be treated.

[0022] It is also possible to make an annular passage between said holed electrode and said lance that is free to move in said hole in order to introduce into the arc

zone also a gas suitable for the formation of a plasma.

[0023] Preferably this electrode has a mixed structure, with the lower part, which is closer to the molten bath and is expendable, made of graphite, and with the upper part made of metal and cooled by water.

[0024] The furnace may also communicate with a gas-tight chamber equipped with devices for feeding into the furnace the materials that are to be treated, if these are solid and are of such a size or consistency as to prevent their introduction through the lance.

[0025] The furnace according to the invention may be of the direct-current, single-electrode type and with conductive hearth.

Claims

1. Process for the thermal destruction of hazardous materials, in which said materials are exposed in a furnace to radiant heat from the metal bath and from furnace walls, **characterised in that** the material itself is introduced into the electric arc of an operating electric arc furnace of the type used in steel making, which contains a molten metal bath, for example cast iron or steel having a temperature of above 1300°C, and in the internal free volume of said furnace the gases resulting from combustion of said material are exposed to the irradiating action of mainly the electric arc, for a time above 3 seconds.
2. Process according to claim 1, **characterised in that** in the area of the electric arc plasma conditions are created by feeding a suitable gas.
3. Process according to claim 1, **characterised in that** the material to be treated is fed through a lance which is introduced axially and is free to move inside a hollow electrode used to form said electric arc.
4. Process according to claim 2, **characterised in that** said gas is chosen from between nitrogen and argon and is fed in through an annular passage defined between the internal walls of said hollow electrode and the external walls of said lance.
5. Process according to claim 1, **characterised in that** said time is in excess of 6 seconds, and preferably between 8 and 15 seconds.
6. Device for thermal destruction of toxic-harmful materials, consisting of an electric-arc furnace of the type used in steelmaking, sealed or operated in negative pressure to prevent any gas leakage into the environment, **characterised by** the use, to form the electric arc, of at least one electrode having an axial hole and bearing in said hole a metal lance that is free to move axially for feeding the material

to be treated directly into the area of the electric arc.

7. Device according to Claim 6, **characterised by** the presence between the holed electrode and the lance that can move freely inside the electrode, of an annular passage for feeding into the area of the electric arc a suitable gas for the formation of a plasma.
8. Device according to Claim 6, **characterised in that** said electrode has a mixed structure, with the lower part, which is closer to the molten metal bath and is expendable, made of graphite, and with the upper part made of metal and cooled by water.
9. Device according to Claim 6, **characterised in that** it is further equipped with a gas-tight chamber communicating with the inside of the furnace, equipped with devices for feeding into the furnace solid materials that are to undergo treatment.

Patentansprüche

1. Verfahren zur thermischen Zersetzung gefährlicher Stoffe, worin die Stoffe in einem Ofen der Wärmestrahlung aus einem Metallbad und aus den Ofenwänden ausgesetzt werden, **dadurch gekennzeichnet, daß** der Stoff selbst in den Lichtbogen eines in Betrieb befindlichen Lichtbogenofens des Typs eingeführt wird, der bei der Stahlherstellung verwendet wird und ein geschmolzenes Metallbad enthält, z.B. Gußeisen oder Stahl mit einer Temperatur von über 1.300°C, und daß im inneren freien Volumen des Ofens die aus der Verbrennung des Stoffes resultierenden Gase der Strahlungswirkung hauptsächlich des Lichtbogens für eine Dauer von mehr als 3 Sekunden ausgesetzt werden.
2. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, daß** im Bereich des Lichtbogens Plasmabedingungen durch Zuführen eines geeigneten Gases geschaffen werden.
3. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, daß** der zu behandelnde Stoff durch eine Lanze zugeführt wird, die axial eingeführt wird und sich frei innerhalb einer hohlen Elektrode bewegen kann, die zur Bildung des Lichtbogens verwendet wird.
4. Verfahren gemäß Anspruch 2, **dadurch gekennzeichnet, daß** das Gas aus Stickstoff und Argon ausgewählt wird und durch einen ringförmigen Durchgang zugeführt wird, der zwischen den Innenwänden der hohlen Elektrode und den Außenwänden der Lanze definiert wird.

5. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, daß** die Dauer mehr als 6 Sekunden und bevorzugt zwischen 8 und 15 Sekunden beträgt.

6. Vorrichtung zur thermischen Zersetzung toxisch-schädlicher Stoffe, die aus einem Lichtbogenofen des Typs besteht, der bei der Stahlherstellung verwendet wird, versiegelt oder unter negativem Druck betrieben, um eine etwaige Gasleckage in die Umgebung zu verhindern, **gekennzeichnet durch** die Verwendung, zur Bildung des Lichtbogens, wenigstens einer Elektrode mit einem axialen Loch, die in dem Loch eine Metalllanze führt, die sich axial frei bewegen kann, um den zu behandelnden Stoff direkt in den Bereich des Lichtbogens zu führen.

7. Vorrichtung gemäß Anspruch 6, **gekennzeichnet durch** das Vorhandensein eines ringförmigen Durchgangs zwischen der hohlen Elektrode und der Lanze, die sich frei innerhalb der Elektrode bewegen kann, zur Zufuhr eines geeigneten Gases zur Bildung eines Plasmas in dem Bereich des Lichtbogens.

8. Vorrichtung gemäß Anspruch 6, **dadurch gekennzeichnet, daß** die Elektrode eine Mischstruktur aufweist, wobei der untere Teil, der sich näher zum geschmolzenen Metallbad befindet und entbehrlich ist, aus Graphit hergestellt ist, und der obere aus Metall hergestellt ist und durch Wasser gekühlt ist.
9. Vorrichtung gemäß Anspruch 6, **dadurch gekennzeichnet, daß** sie ferner mit einer gasdichten Kammer ausgerüstet ist, die mit dem Inneren des Ofens in Verbindung steht, ausgerüstet mit Vorrichtungen zur Zufuhr fester Stoffe, die die Behandlung erfahren sollen, in den Ofen.

Revendications

1. Procédé pour la destruction de matières dangereuses, dans lequel lesdites matières sont exposées dans un four à la chaleur radiante du bain de métal et des parois, **caractérisé en ce que** la matière elle-même est introduite dans l'arc électrique d'un four à arc électrique du type utilisé dans la fabrication de l'acier, qui contient un bain de métal fondu, par exemple de fonte ou d'acier ayant une température supérieure à 1.300°C, et dans le volume interne libre duquel four les gaz provenant de la combustion de ladite matière sont exposés à l'action irradiante principalement de l'arc électrique, pendant une période de temps supérieure à 3 secondes.
2. Procédé selon la revendication 1, **caractérisé en ce que** des conditions de plasma sont créées dans la zone de l'arc électrique par apport d'un gaz ap-

proprié.

3. Procédé selon la revendication 1, **caractérisé en ce que** la matière à traiter est introduite par une lance qui est engagée axialement et est libre de se déplacer à l'intérieur d'une électrode creuse utilisée pour former ledit arc électrique. 5

4. Procédé selon la revendication 2, **caractérisé en ce que** ledit gaz est choisi parmi l'azote et l'argon et est introduit par un passage annulaire défini entre les parois internes de ladite électrode creuse et les parois externes de ladite lance. 10

5. Procédé selon la revendication 1, **caractérisé en ce que** ladite période de temps est supérieure à 6 secondes et de préférence entre 8 et 15 secondes. 15

6. Dispositif pour la destruction thermique de matières toxiques nuisibles, constitué d'un four à arc électrique du type utilisé dans la fabrication de l'acier, scellé ou fonctionnant sous pression négative pour empêcher toute fuite de gaz dans l'environnement, **caractérisé par** l'utilisation, pour former un arc électrique, d'au moins une électrode ayant un trou axial et portant dans ledit trou une lance de métal qui est libre de se déplacer axialement pour introduire la matière à traiter directement dans la zone de l'arc électrique. 20
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7. Dispositif selon la revendication 6, **caractérisé par** la présence, entre l'électrode creuse et la lance qui peut être déplacée librement à l'intérieur de l'électrode, d'un passage annulaire pour introduire un gaz approprié à la formation du plasma dans la zone de l'arc électrique. 30
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8. Dispositif selon la revendication 6, **caractérisé en ce que** ladite électrode a une structure mixte, la partie inférieure qui est plus proche du bain de métal fondu et est extensible, étant faite en graphite, et la partie supérieure étant faite en métal et refroidie par eau. 40

9. Dispositif selon la revendication 6, **caractérisé en ce qu'il** est en outre équipé d'une chambre étanche aux gaz communiquant avec l'intérieur du four, équipé de dispositifs pour introduire dans le four des matières solides qui doivent subir le traitement. 45
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