

**PROCESS AND PLANT FOR INCINERATING WASTE WITH
PREHEATING OF THE LATTER**

The invention relates to a method for incinerating
5 household or industrial waste in a reactor with
preheating of the waste by a steam circuit the steam
for which comes from the steam expansion turbine (TRV).

The object of the invention is to obtain within the
10 incinerator complete combustion without any unburnt
matter, without any troublesome residue, without
releasing gas into the atmosphere, in order to protect
the environment from any pollution.

15 Another object of the invention is to recuperate the
thermal energy released, to convert it into electrical
energy, and to reuse some of this energy within the
plant itself. The amount of electrical energy
recuperated is approaching 75%, excluding the energy
20 reinjected into the plant.

These objects are achieved by the invention which
consists in a process for incinerating household or
industrial waste in a combustion reactor, characterized
25 in that:

- the combustion is carried out under pressure and
with the addition of pure oxygen to the reactor,
and in the absence of nitrogen,
- the steam from the expansion turbine is tapped off
30 to preheat the waste before it enters the reactor,
- then the remaining gases are condensed in order to
recuperate them.

Furthermore, the method is characterized in that the
35 oxygen needed for combustion is produced by separating
the nitrogen and oxygen from the air, the nitrogen thus
produced being used in particular to cool the gases
resulting from the combustion of the waste, and the

oxygen being injected into the reactor at at least one point.

5 The method as defined allows better destruction of dioxins, unburnt matter, compounds of nitrates, carbonates and phosphates which give rise to oxides

10 A plant according to the invention, in order to implement the process, is characterized in that it comprises:

- a feed hopper (TA) having at its inlet and at its outlet a shutter and comprising means;
 - a feed screw capable of preheating the waste using steam tapped from the expansion turbine (TRV);
 - 15 - an intermediate hopper able to collect the waste reheated in the feed hopper and introduce it into the top of the reactor, and
 - a reactor equipped with three burners, these being a main burner (BP), an auxiliary burner (BA) and a catalytic burner (BC) positioned near the combustion gases outlet, each of these three burners being fed with fuel by the fuel line (3) and with pure oxygen by an oxygen production circuit (5), the core of the reactor comprises a cathode wall based on metals of the tungsten or tantalum type, chosen for their refractory nature.
- 20
- 25

As a preference, the oxygen is produced by separating air into nitrogen and oxygen.

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The invention will be better understood with the aid of the description which follows, given with reference to the following attached figures:

- 35
- figure 1: an overview of a waste incineration plant according to the invention,
 - figure 2: a diagram of the water vaporization circuit of the plant,

- figure 3: a detailed diagram of the feed hopper and of the feed screw according to the invention.

5 Reference is made first of all to figure 1 which shows a plant in its entirety, this plant essentially comprising:

- an incineration line 1,
- 10 - a steam circuit 2,
- a fuel feed line 3,
- a nitrogen circuit 4,
- an oxygen circuit.

15 **Incineration line (1).**

Trucks containing the waste that is to be destroyed are unloaded under gravity into a feed hopper (TA) the outlet of which is equipped with a shutter (OF1).

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A feed screw (VA) receives the waste from the feed hopper (TA) and conveys it and tips it into an intermediate hopper (TI) via an inlet situated at the top of said hopper (TI) and equipped with a shutter
25 (OF2).

The feed screw (VA) also allows the waste to be preheated as will be explained later on. The intermediate hopper (TI) has a central bottom outlet
30 equipped with a shutter (OF3) and via which it loads the waste under gravity into an inlet chute opening onto an opening shutter (OF4) of a combustion reactor (RC) and at the top thereof.

35 For preference, the hopper (TI) is pressurized at a temperature close to 900°C to accelerate the reforming of and removal of halides from the POPs in order to facilitate the expulsion of waste to the combustion reactor. Advantageously, the pressurizing will be

performed by introducing a mass of steam at high pressure and high temperature in excess of 1000°C into the hopper (TI) via at least one appropriate orifice. This gaseous mass at high pressure will have the advantage of fluidizing the mass of waste present in the hopper TI and as a result of making it easier to cause it to flow to the combustion reactor (RC). In order to prevent any leak of gaseous mass from the intermediate hopper to the hopper TA while said intermediate hopper is being filled, the orifice via which the gaseous mass is introduced will be associated with a remote-controlled valve. This valve will be in the position of closing off the orifice when the hopper loading hatch is in the open position and will be in the position in which the orifice is open when the loading hatch of the intermediate hopper is in the closed position.

It will be possible to use several hoppers each in turn communicating with the feed hopper and each in turn communicating with the reactor RC. This arrangement will allow one intermediate hopper to be filled from the feed hopper when the other or one of the other hopper(s) is in the process of unloading into the reactor (RC).

It will be possible to incorporate, after the feed hopper, a tank that will allow the waste to be mixed with an additive based on sodium hydroxide or on potassium hydroxide in order, at temperatures close to 200°C, to neutralize acids in a first phase and the halides bound up in the inorganic molecules.

Halides present in the POPs (persistent organic pollutants) will be eliminated or fixed using alkali metal hydroxides in the intermediate hopper at temperatures close to 1000°C.

The combustion of waste produces fly ash and gases. The fly ash drops to the bottom of the reactor (RC) and then into a bottom ash hopper (TC) situated under the reactor (RC). This bottom ash hopper conveys the fly
5 ash to an ash cooling recuperator (RCE) via a shutter (OF5). The recuperator RCE mixes the fly ash with water and initiates reactions between the oxides and the water to form soluble hydroxides. Next, the insoluble fly ash is tipped into a truck which takes it away
10 (1c).

All the fly ash, except for the air pollution control residue (APCR) will be processed using water at temperatures of between 200 and 400°C, at the outlet
15 from the reactor. No additional energy is needed to obtain these temperatures because the dilution of alkali metal oxides is exothermal.

A processing circuit enables soluble waste to be
20 separated from insoluble waste, the insoluble waste being sent for sedimentation and some of the soluble content will crystallize and be able to be reused. The soluble part will be reintroduced into the feed hopper following the separation of the salts of the halides,
25 and of the sulfates of potassium and of sodium.

The combustion reactor (RC) is equipped with refractory bricks for good thermal insulation and a cathode wall based on tungsten or tantalum at the heart of the
30 reactor ensures that the waste is burnt at very high temperatures ranging between 1500-3000°C, and is so using three burners (BP, BA, BC) fed with fuel and with oxygen and respectively:

- 35 - a main burner (BP) positioned at the base of the combustion reactor (RC),
- an auxiliary burner (BA) positioned in the middle part of the combustion reactor (RC),

- a catalytic burner (BC) positioned at the upper part of the reactor and near the outlet of the gases, combustion gases 5 completing and optimizing the combustion.

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The primary and auxiliary burners operate with an excess of oxygen at a rate of reaction 10 to 20 times higher than the habitual speed of combustion reactions.

- 10 The reactor (RC) is designed to operate at constant high pressure and constant high temperature, and its inlets and outlets therefore consist of hatches that constitute heat shields and provide sealing.

- 15 The combustion reactor will preferably be a thermal oxidation reactor (TOR).

The hoppers also operate under pressure and consist of air locks with their inlet and outlet shutters.

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Safety valves CE1 and CE2 are also provided in the reactor and in the intermediate hopper.

- 25 The shutters OF1 to OF5 can be actuated by motors external to the elements to which they are fitted. The motors will be of any known type. Without implying any limitation, they could consist of remote-controlled electric, hydraulic or pneumatic cylinder actuators.

- 30 The combustion gases are capped from the outlet (1a) at the top of the reactor (RC) and sent through a pipe (SGC) to a particulate filter (PF) and then into heat exchangers ECT1, ECT2 toward an expansion turbine (TRGC).

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The expansion turbine (TRGC) is advantageously associated with an electric energy generator (GE3) and so some of the heat energy of the combustion gases is thus converted into electricity.

The water vapor is condensed and the gaseous oxides are removed (1b) to (CGC). Some of the water from CV2 is reintroduced into the compressor (7), having passed
5 through an osmotic filter.

Steam circuit (2)

Advantageously, some of the condensed water can be
10 recuperated and vaporized into the form of high-pressure and high-temperature dry steam to form the high-pressure gaseous mass introduced into the intermediate hopper. Thus, upon leaving the condenser (CV1) the water will be bled to a heat exchanger 6
15 where it is vaporized into the form of high-pressure dry steam. Advantageously, the heat exchanger may consist of a tube bundle in thermal contact with the reactor (RC) to recuperate some of the heat given off by the latter, thereby stabilizing the temperature
20 inside the reactor, this heat being used to vaporize the water and most of the steam being directed to an expansion turbine (TRV), another proportion of it being injected into a pipe (TI).

25 The steam leaving the TRV is introduced into a preheating device (SP) incorporated into an endless feed screw (VA) provided between the feed hopper (TA) and the intermediate hopper (TI). This feed screw (TA) comprises a longitudinal shaft (2d) on which a screw
30 thread (2c) is mounted. A drive member of any known type will be coupled to the shaft of the screw.

The preheating device (SP) is preferably, but nonlimitingly, that of figure 3 which consists of a
35 screw thread (2c) in the form of a box with a gas inlet downstream to the screw and a gas outlet upstream to the screw, the gas outlet being between the screw thread and the inlet shutter (OOF1). The upstream and downstream inlets are each formed of a blind axial

drilling made in the shaft (2d) at a corresponding end and of a radial drilling made in said shaft and opening, at one end, into the blind axial drilling and into the box form that the screw thread (2c) exhibits.

5 The steam is injected axially into the start of the screw thread and heats up the waste as it travels along the screw thread, then leaves the thread to be sent to a first condenser (CV1), having passed through a compressor 7.

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As a preference, a compressor 7 may be positioned upstream of the exchanger 6 to pressurize the water and create at this point a back pressure that prevents the reflux of steam to the condenser (CV1).

15 It may be pointed out that the circulation of steam through the screw is countercurrent with respect to the progress of the waste carried by this screw.

20 The condensers (CV1, CV2, CGC) are of the conventional type with tube-type heat exchangers through which a refrigerant from an evaporator-type refrigeration device (EFF) passes.

25 The tapped-off combustion gases are gases which are oxidized and stabilized without dioxin and without unburnt matter in the duct SGC. Some of their heat energy is converted into electrical energy in a generator associated with the turbine (TRGC) and most of the energy is used to heat up the nitrogen.

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Following cooling using nitrogen, the combustion gases are conveyed to ECT1 and ECT2. These gases are condensed and then introduced into the turbine TRGC which converts the energy of the combustion gases back into electrical energy. Following expansion, the gases are separated from the steam, because the latter condenses.

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This water circuit (1d) also contains at least one means (for example using osmosis filtration) of inerting the water that has been condensed in the condenser (CV2).

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Fuel line (3)

To feed fuel along a line (3), provision is made for the fuel to be taken from a tank (RCA) and injected under high pressure into each of the three burners, namely the main burner (BP), the auxiliary burner (BA) and the catalytic burner (BC).

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Nitrogen circuit (4)

A bank of air compressors (BCA) compresses the atmospheric air from one bar to about 300 bar, this air being cooled after each compression stage in heat exchangers using the refrigerant conveyed along a pipe (4a) from the refrigeration device (EFF) already mentioned.

A turbocompressor (TCA) expands the air from 300 bar to about 50 bar, this expansion being accompanied by a cooling of the air from -43° (approximately, on leaving the heat exchanger of the final compression stage) down to -134° approximately, thus allowing the gaseous nitrogen to be separated from the liquefied oxygen inside an air expansion vessel (BDA).

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The same turbocompressor (TCA) recompresses the gaseous nitrogen from about 50 bar to about 280 bar, liquefies some of it in RAL and sends the remainder of the gaseous nitrogen to a nitrogen tank RAG.

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The nitrogen is then sent from the tank (RAG) to a heat exchanger (CFF2) where it is heated back up to about 61°C then sent into the tube-type heat exchangers ECT1, ECT2 in order to cool the combustion gases to 200°C .

The nitrogen is heated back up to about 900°C countercurrent to the combustion gases. The nitrogen is then sent into the nitrogen recuperation turbine (TRA) associated with an electric generator GE3. In this way,
5 the nitrogen is used to recuperate heat energy, which energy becomes converted into electrical energy by the generator GE3.

The nitrogen separation circuit that has just been
10 described by way of nonlimiting example is intended to avoid the encumbrance associated with nitrogen the atmospheric air content of which is 78%, and associated with the production of unwanted NOx.

15 **Oxygen circuit (5)**

A paramagnetic separator separates the liquid oxygen from the gaseous nitrogen leaving the expansion vessel BDA.

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The liquid oxygen is sent to a liquid oxygen tank (ROL). Following storage, it is preheated in an exchanger CFF2 from -134° to approximately 0° at which it turns into a gas and is directed to the reactor RC
25 to feed each of the three burners (BP, BA, BC).

The oxygen feed to the burners encourages complete combustion of the waste.

30 An additional catalytic burner (not depicted), also fed with oxygen, also allows dioxin molecules to be broken down and the elimination of any unburnt matter.

The means just described for separating the air into
35 oxygen and nitrogen is used in preference for high-capacity incinerators according to the invention.

For incinerators according to the invention, but which are of low capacity, it may be preferable to use air

separators operating using membrane filters to separate the oxygen and the nitrogen, this type of separator making it possible to obtain the oxygen and the nitrogen directly in gaseous form.

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The advantages afforded by this novel type of incinerator are as follows:

- 10 - to incinerate the same amount of waste, the volume of the incinerator is markedly lower than that of the incinerators currently in use,
- 15 - the use of oxygen in place of air reduces the volume of oxidizer by the 79% of nitrogen contained in atmospheric air. High-pressure operation within the incinerator speeds up the rate of combustion of waste in the presence of oxygen, the absence of nitrogen allowing direct contact with the oxidizer,
- 20 - the recuperation of the nitrogen from the separation of air makes it possible in high-capacity incinerators to produce energy using the recuperation turbines coupled to an electric generator,
- 25 - because the incinerator operates under pressure, the combustion gases produce energy through the use of recuperation turbines each coupled to an electric generator,
- 30 - given the operating characteristics of this novel type of incinerator, the investment required to incinerate the same amount of waste is lower than that required with present-day incinerators,
- 35 - the closed-circuit operation achieved thanks to the recirculation of the oxidized gases avoids any discharge of gas into the atmosphere,

- the plant can incinerate all kinds of waste including asbestos and drilling sludge for example.

CLAIMS

1. A process for incinerating household or industrial waste in a reactor (RC), characterized in that:
 - 5 - the combustion is carried out under pressure and with the addition of pure oxygen to the reactor, and in the absence of nitrogen,
 - the steam from the expansion turbine is tapped off to preheat the waste before it enters the reactor,
 - 10 - then the remaining gases are condensed in order to recuperate them.

2. The method as claimed in the preceding claim, characterized in that the oxygen needed for combustion
15 is produced by separating the nitrogen and oxygen from the air, the nitrogen thus produced being used to cool the gases resulting from the combustion of the waste, and the oxygen being injected into the reactor at at least one point.
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3. A plant for incinerating household or industrial waste, of the type comprising a reactor (RC) with at least one burner fed by a fuel feed line (3), characterized in that it comprises:
 - 25 - a feed hopper (TA) having at its inlet and at its outlet a shutter and comprising means capable of preheating the waste using steam tapped from the expansion turbine (TRV)
 - an intermediate hopper (TI) able to collect the
30 waste preheated in the feed hopper and introduce it into the top of the reactor,
 - a reactor equipped with three burners, these being a main burner (BP), an auxiliary burner (BA) and a catalytic burner (BC) positioned near the
35 combustion gases outlet, each of these three burners being fed with fuel by the fuel line (3) and with pure oxygen by an oxygen production circuit (5).

4. The plant as claimed in the preceding claim, characterized in that the feed hopper means capable of reheating the waste consists of a screw thread (2c) in the form of a box with a gas inlet downstream to the screw and a gas outlet upstream to the screw, the gas outlet being at the other end between the screw thread and the inlet shutter (0F1).

5. The plant as claimed in one of claims 3 and 4, characterized in that it comprises a steam circuit (2) attached to the walls of the reactor.

6. The plant as claimed in the preceding claim, characterized in that the steam recovery circuit comprises at least one condenser (CV1).

7. The plant as claimed in one of claims 3 to 6, characterized in that it comprises an air separator operating using membrane filters to separate the oxygen and the nitrogen.

8. The plant as claimed in one of claims 3 to 6, characterized in that it comprises an air separator formed of a bank of air compressors (BCA) and of a turbocompressor TCA able to separate gaseous nitrogen from liquefied oxygen.

9. The plant as claimed in claim 8, characterized in that the oxygen production circuit (5) comprises, after the air separator and the turbocompressor, an expansion vessel (BDA), a liquid oxygen storage tank (ROL), an exchanger (CFF2) in which the oxygen is gasified to be fed to each of the three burners (BP, BA, BC).

10. The plant as claimed in claim 8, characterized in that it comprises, after the air separator and the turbocompressor, an expansion vessel (BDA), a nitrogen tank (RAG), three heat exchangers (CFF2, ECT1, ECT2)

then a tube-type heat exchanger and a nitrogen recuperation turbine (TRA).

11. The plant as claimed in one of claims 5 and 6,
5 characterized in that the expansion turbine (TRV) is associated with an electric generator.

12. The plant as claimed in any one of claims 3 to 11,
10 characterized in that the hopper (TI) is pressurized to facilitate the expulsion of waste to the combustion reactor.

13. The plant as claimed in claim 12, characterized in that the pressurizing of the intermediate hopper (TI)
15 is performed by introducing a gaseous mass under high pressure into said hopper (TI) via at least one appropriate orifice.

14. The plant as claimed in claim 13, characterized in
20 that the orifice via which the gaseous mass is introduced into the intermediate hopper (TI) is associated with a remote-controlled valve in order to prevent any leakage of gaseous mass from the intermediate hopper to the hopper (TA) while said
25 intermediate hopper is being filled.

15. The plant as claimed in claim 12 or claim 13, characterized in that the gaseous mass is high-pressure dry steam.

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16. The plant as claimed in claim 4, characterized in that the gases leaving the screw thread of the screw are sent to a first condenser (CV1) the purpose of which is to condense the water vapor contained in the
35 combustion gases, having passed through a compressor (7).

17. The plant as claimed in claims 15 and 16 considered together, characterized in that some of the

water condensate leaving the condenser (CV2) is bled off to a heat exchanger (7) where it is vaporized to the form of high-pressure dry steam.

- 5 18. The plant as claimed in claim 17, characterized in that the heat exchanger consists of a tube bundle in thermal contact with the reactor (RC) to recuperate some of the heat given off thereby, this heat being used to vaporize the water.
- 10 19. The plant as claimed in claim 18, characterized in that a compressor (7) is positioned upstream of the exchanger to pressurize the water and to create at this point a back pressure which prevents the reflux of
- 15 steam toward the condenser (CV1).
- 20 20. The plant as claimed in any one of claims 3 to 19, characterized in that after cooling using nitrogen, the combustion gases are conveyed to ECT1 and ECT2; these combustion gases are condensed then introduced into the turbine TRGC; after expansion, the gases become separated from the condensed water.