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(54) INCINERATION OF WASTE

(71) We, KERNFORSCHUNGSANLAGE JÜLICH GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, of Postfach 1913, 5170 Jülich, Federal Republic of Germany, a Body Corporate organised according to the laws of the Federal Republic of Germany and KRAFTANLAGEN AKTIEGESELLSCHAFT, of Im Breitspiel 7, Postfach 10 34 20, 6900 Heidelberg 1, Federal Republic of Germany, a Body Corporate organised according to the laws of the Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of burning waste material, and to an incinerator for this purpose.

U.K. Patent Specification 1 365 125 describes an installation which is for the combustion of solid waste and which has two vertical, adjoining chambers one above the other, an upper chamber for pyrolysis of the waste and a lower chamber for combustion of the pyrolysed material. The pyrolysis chamber has almost constant cross section and leads directly to the combustion chamber below. The combustion chamber is annular and houses grate surfaces which are set at an inclination to the vertical. The solids sliding down over the grate are attacked by the burner flames, burnt out and melted. The grate serves also as the upper cover of a slag chamber. The molten slag produced in the combustion chamber from the pyrolysis residues are led into the slag chamber and cooled at its bottom by means of a water receiver. Part of the waste gases from the combustion chamber is piped upwards and in counterflow direction to the waste material through gasification, degassing and drying section of the pyrolysis chamber. Thus, heat exchange is effected. The gases developed in the pyrolysis chamber leave this chamber at its top and are chilled outside the installation. Corrosive agents are eliminated. Subsequently, these gases are led again through pipes into both the drying section of the pyrolysis chamber and, as additional fuel, into the combustion chamber.

As already mentioned, the gases from the pyrolysis process which leave the pyrolysis chamber at its top are chilled. Liquid constituents are separated in a separator. Prior to being reused as fuel gas, the constituents of the pyrolysis gases which cannot be condensed are led in counterflow direction to the hot unpurified pyrolysis gases in order to cool them. Outside the installation, the waste gases from the combustion chamber which are not led into the pyrolysis chamber, give off their waste heat to the combustion air led through pipes to the gasification zone and to below the grate. Prior to this waste gas flow being discharged through the stack, the waste heat from the flue gases is utilized for external heat consuming appliances and dust particles are eliminated by means of a filter of conventional construction.

This installation can burn various kinds of waste and, by melting, convert the waste into slag.

However, when waste materials and gases are led in counterflow direction through the pyrolysis chamber for the purpose of direct heat exchange, as is the case in the installation just described, partial or complete utilization of the pyrolysis gases in the combustion process requires these gases to be first passed through external heat exchangers and purification equipment. This entails very complex and expensive installations.

According to one aspect of this invention there is provided an incinerator for burning waste material having a pair of adjoining chambers disposed one above the other, the chambers being an upper chamber for pyrolysis and a lower chamber for combustion; at least one dividing element separating the chambers, the or each element being moveable to provide one or more apertures of varying widths for the passage of solid and gaseous products of the pyrolysis into the combustion chamber; at least one passageway for the supply of combustion air opening into the combustion chamber below the dividing element or elements; and one or more waste ducts extending from the combustion chamber and at least partially overlying the walls of the pyrolysis chamber, the overlain wall regions being walls both of the pyrolysis chamber and of the waste gas ducts. The or each dividing element may be pivotally mounted, e.g. on a shaft or axle and may be devoid of through apertures from its surface adjoining the pyrolysis chamber.

Preferably slenderness of the pyrolysis chamber is engineered so that during the passage of waste material through the pyrolysis chamber heat from the waste gas ducts completely penetrates the fill.

During operation of the incinerator heat from the exothermic combustion processes in the combustion chamber is led back into the pyrolysis chamber and is reused for the endothermic pyrolysis processes. A certain minimum mean calorific value of the solid waste is prequisite.

The calorific value required can be achieved simply by adding waste of high calorific value to any waste with low calorific value. This obviates auxiliary firing by means of fuel of high calorific value.

By appropriate selection of the shape and dimensions of the cross section of the pyrolysis chamber large wall surfaces can be made available for heat transfer from the combustion gases to the solid waste. Moreover a consequence of a slender chamber is that heat conduction from the chamber walls to the centre of the fill is not impaired by long distances for the heat to travel.

Preferably an internal dimension of the cross section of the pyrolysis chamber is not more than 1000 mm, the waste gas ducts overlying at least those walls of the pyrolysis chamber which enclose this internal dimension.

The pyrolysis chamber may advantageously be of rectangular cross section, the width of the chamber being from 300 to 1000 mm and the ratio of chamber width to chamber length being from 1:1 to 1:5. With this arrangement waste gas ducts may overlie each of one pair of opposed walls of the pyrolysis chamber, while at least part of the other pair of opposed walls are not overlain by waste gas ducts so that mountings, actuation appliances or drive units for the dividing elements may be provided near or on these walls.

In an advantageous form of incinerator, the or each dividing element has outlets for combustion air on its side facing the combustion chamber, and the said passageway or passageways for the supply of combustion air communicates with the or each dividing element, so that combustion air may be delivered to the combustion chamber through the said outlets. In consequence, the dividing elements are cooled by the combustion air.

For supplying air to the lowest part of the pyrolysis chamber there may be at least one passageway for the supply of air opening into the pyrolysis chamber above the dividing element or elements.

An arrangement which is particularly space-saving and which can give reliability in operation can be achieved should increasing processing capacities be required, by disposing a plurality of incinerators forming a series, with the pyrolysis chambers of neighbouring incinerators side by side, and with a common waste gas duct between each two neighbouring pyrolysis chambers.

For starting the incinerator, burners may be provided before and/or after the dividing elements as seen in the direction of flow. In order to be protected and to ensure easy accessibility these burns may be installed at the top end of burner shafts arranged on opposed chamber walls (in case of a rectangular chamber cross section on the narrow sides).

In order to guarantee the necessary combustion temperatures even in case of waste not having the minimum calorific value, auxiliary burners may be provided. As the start-up burners of the pyrolysis chamber, such auxiliary burners may be positioned below the dividing elements in the walls of the lower combustion chamber and mounted in a way analogous to the mounting of the start-up burners.

The incinerator may have an ash chamber with its central axis offset relative to that of the upper, pyrolysis and the lower, combustion chambers in such a way that it neighbours the chamber wall with the greater width. The total height of the combustion installation can thus be kept low whilst allowing for the required free space for access and for attending to the discharge of ash.

A wide variety of methods is available for the discharge of ash. A slide plate or a slide frame is of advantage, by means of which the ash cone which develops on the bottom of the combustion chamber can be discharged into a chamber for the discharge of ash. For this purpose an auxiliary shaft can be provided on the side of the ash chamber to receive the slide frame as it is withdrawn from the combustion chamber.

This auxiliary shaft may define a rectangular cavity to receive the slide frame and which opens into the ash discharge chamber on one of its four lateral sides, while the other three, as well as its top and bottom, close off the cavity from the atmosphere. In consequence the auxiliary shaft is subject to the same reduced pressure as the combustion chamber with which it communicates.

In another aspect the invention provides a method of burning solid waste — and optionally liquid waste also — comprising charging the waste to the pyrolysis chamber of an incinerator having an upper chamber for pyrolysis adjoining a lower chamber for combustion, the pyrolysis chamber being heated and the chambers being separate by one or more dividing elements moveable to provide one or more apertures of varying widths for the passage of solid and gaseous products of the pyrolysis into the combustion chamber; drying, degassing and gasifying the waste in the pyrolysis chamber; supplying air below the dividing element or elements to provide air in the combustion chamber; burning solid and gaseous products from the pyrolysis in the combustion chamber; and leading heat from the combustion process back through the walls of the pyrolysis chamber to heat it and penetrate completely the waste material therein.

Air may be supplied above the dividing elements in order to provide air in the pyrolysis chamber for the formation of a glowing bed. Preferably this is of sufficient volume and temperature to ensure the maximum possible gasification of the waste material whereby the solidity of the pyrolysis residues is reduced to such an extent that, with movement of the dividing elements, they are crushed to particles which will be burned completely.

Residues from the pyrolysis process which are still combustible are burnt in the combustion chamber.

If the waster content of the waste is insufficient, the waste can either prior to being conveyed into the pyrolysis chamber or in a section of this chamber, be moistened by water or steam so as to promote a complete water-gas reaction.

The dividing elements serve three purposes. They hold back the waste until a glowing bed of sufficient volume has developed; during their movement they discharge only waste particles up to a predetermined size into the combustion chamber, and they effect crush and turning over of the waste in the pyrolysis chamber.

In this method of burning waste the endothermic and exothermic partial processes are spatially separated and can be regulated independently from each other. The process as whole may be clearly controlled by simple monitoring and control operations. A heat cycle is established within the incinerator and waste heat is reused for the internal processes; thus, the pyrolysis and combustion processes can be accomplished largely without additional fuel.

An embodiment of the invention, in the form of an incinerator with a rectangular chamber cross section, will now be described in detail with reference to the accompanying drawing in which:—

Figure 1 is a sectional elevation at the axis of the incinerator and parallel to the chamber side of greater width,

Figure 2 is a sectional elevation of the combustion installation also at the axis of the incinerator but parallel to the chamber side of smaller width.

The incinerator has a pyrolysis chamber 8 above, and directly adjoining, a combustion chamber 12. The chambers are separated by a pair of dividing elements 10*a*, 10*b* at the transition between the two chambers. These dividing elements are pivotally mounted about axes near the side of the incinerator, and swivelling of the elements about these axes varies the gap 18 between them. The pyrolysis gases also pass into the combustion chamber.

As shown in Figure 1, the waste is delivered in barrels 1*a*, 1*b*. These barrels are opened, tilted through 180° by means of tilting equipment 3*a*, 3*b* and placed on feed hoppers 5*a*, 5*b*. After having opened the closures on both the tilting equipment and the feed hoppers, the waste is discharged into the pyrolysis chamber 8 where it settles on the dividing elements 10*a*, 10*b*. On opposed walls of the pyrolysis chamber 8, burners 14*a*, 14*b* are arranged at the top of lateral cavities 16*a*, 16*b* in such a way that the point of intersection of the axes of the flame cones is on the central axis of the incinerator.

On ignition of the burner flames; the heat supplied is concentrated to the centre of the waste fill and the endothermic drying, degassing and gasification processes are started. After the complete operation has been initiated, the burners 14*a*, 14*b* are turned off. By moving the dividing elements downwards and back again into a horizontal position — either manually by an external handle (not shown) or by a drive unit —, either the gap 18 can be widened or reduced while at the same time a turning over of the contents of the pyrolysis chamber is effected. Together with the endothermic processes, this movement of the chamber contents causes crushing of the pyrolysis residues. Solid residues which are sufficiently small pass through the gap 18 fall into the lower combustion chamber 12. Any which still contain combustible material are completely burnt in the combustion chamber. Combustion air required for the combustion of the pyrolysis products — which takes place in the lower combustion chamber — is supplied by means of connections 9*a*, 9*b* which are provided near the swivel axes of the dividing elements. Combustion air flows through the dividing elements and enters the combustion chamber 12 through openings 11*a*, 11*b* provided at the underside of the dividing elemetns 10*a*, 10*b*. The combustion air also serves to cool the dividing elements, thus protecting them against excessive heating which might be caused by the processes accomplished in the upper, pyrolysis and the lower, combustion chamber.

As best seen from Figure 2, waste gas ducts 28*a*, 28*b* extend from the combustion chamber 12 and overlie both of the wider side surfaces of the pyrolysis chamber 8. The walls which provide the wider side surfaces of the pyrolysis chamber also constitute walls of the waste gas ducts, so that external surfaces of the pyrolysis chamber are internal surfaces of the waste gas ducts. As waste gases are withdrawn from the combustion chamber 12, they contact the sides of the pyrolysis chamber 8 and heat it and its contents. The slenderness of the pyrolysis chamber enables the heat to penetrate to the centre of the fill of waste material in the pyrolysis chamber.

Filters 30*a*, 30*b* are arranged in the ducts 28*a*, 28*b*. The waste gases flow through these filters prior to entering a collecting duct 32*a* and thence the waste gas connectors 32 through which the gases are led out of the incinerator.

It will be seen that the wider walls of the pyrolysis chamber are used for heat transfer, while the narrower walls support the dividing elements 10*a*, 10*b* and the burners 14*a*, 14*b*.

At the bottom of the combustion chamber there is an ash discharge frame 19 which encloses the developing ash heap. By means of this frame, the burnt ash constituents are discharged — laterally in Figure 1 — into an ash chamber 20. A discharge gate 22 is connected to the bottom of the ash chamber (in Figure 1 the sluice is provided at the right side) through which the cooled ash is discharged into an ash drum 24 with lid closure 26 by means of an ash conveyor 21.

As best seen from Figure 2, the chamber 20 for the discharge of ash is laterally offset from the axis of the incinerator and is equipped with a spraying device 20*a* serving the purpose of accelerating the cooling of the ash. A water pipe system (not shown) is connected to a connector 20*b* on the cover of the ash chamber 20. An auxiliary shaft 20*c* defines an enclosed cavity which receives the ash discharge frame 19 when it is drawn out of the bottom of the combustion chamber to its final position on the ash chamber side.

The incinerator described above can burn simultaneously both solid waste and waste assuming a pasty state. Pretreatment is not necessary. If required, liquid waste can be burnt, too. The incinerator is suitable for the combustion of house waste, special waste, radioactive waste and hospital waste. These have often been incinerated in separate installations of differing constructions, with various external auxiliary devices, especially heat exchangers and separators. In many instances these separate installations have been operated side by side.

The incinerator described above can, even with discontinuous feeding, economically carry out the pyrolysis and combustion of waste materials of varying combustibility. Yet, its construction is not unduly complex. The incinerator can be combined in a simple manner with further incinerators to accommodate growing demand, and without deleteniously affecting its reliability.

WHAT WE CLAIM IS:—

1. An incinerator for burning waste material having a pair of adjoining chambers disposed one above the other, the chambers being an upper chamber for pyrolysis and a lower chamber for combustion;
at least one dividing element separating the chambers, the or each element being moveable to provide one or more apertures of varying widths for the passage of solid and gaseous products of the pyrolysis into the combustion chamber;
at least one passageway for the supply of combustion air opening into the combustion chamber below the dividing element or elements; and
one or more waste gas ducts extending from the combustion chamber and at least partially overlying the walls of the pyrolysis chamber, the overlain wall regions being walls both of the pyrolysis chamber and of the waste gas ducts.

2. An incinerator according to claim 1 wherein the or each dividing element is pivotally mounted, and which is without through apertures from its surface adjoining the upper, pyrolysis chamber.

3. An incinerator according to claim 1 or claim 2 wherein the width of the pyrolysis chamber between overlain wall region thereof is sufficiently small that heat from the waste gas duct or ducts completely penetrates the waste material in the pyrolysis chamber during its passage therethrough.

4. An incinerator according to claim 1 or claim 2 wherein an internal dimension of the cross section of the pyrolysis chamber is not more than 1000 mm, the waste gas ducts overlying at least those walls of the pyrolysis chamber which enclose this internal dimension.

5. An incinerator according to claim 4 wherein the pyrolysis chamber is of rectangular cross section the width of the chamber being from 300 to 1000 mm and the ratio of chamber width to chamber length being from 1:1 to 1:5.

6. An incinerator according to claim 5 wherein waste gas ducts overlie each of one pair of opposed walls of the pyrolysis chamber, while at least part of the other pair of opposed walls are not overlain by waste gas ducts.

7. An incinerator according to any one of the preceding claims wherein the or each dividing element has outlets for combustion air on its side facing the combustion chamber, and the said passageway or passageways for the supply of combustion air communicates with the or each dividing element, so that combustion air may be delivered to the combustion chamber through the said outlets.

8. An incinerator according to any one of the preceding claims having at least one passageway for the supply of air opening into the pyrolysis chamber above the dividing element or elements.

9. An incinerator substantially as herein described with reference to the accompanying drawing.

10. A combustion installation having a plurality of incinerators according to any one of the preceding claims, the incinerators being disposed with the pyrolysis chambers of neighouring incinerators side by side forming a series, and with a common waste gas duct between each two neighbouring pyrolysis chambers.

11. A method of burning solid waste — and optionally liquid waste also — comprising charging the waste to the pyrolysis chamber of an incinerator having an upper chamber for pyrolysis adjoining a lower chamber for combustion, the pyrolysis chamber being heated and the chambers being separated by one or more dividing elements moveable to provide one or more apertures of varying widths for the passage of solid and gaseous products of the pyrolysis into the combustion chamber;
drying, degassing and gasifying the waste in the pyrolysis chamber;
supplying air below the dividing element or elements to provide air in the combustion chamber;
burning solid and gaseous products from the pyrolysis in the combustion chamber;
and leading heat from the combustion process back through the walls of the pyrolysis chamber to heat it and penetrate completely the waste material therein.

12. A method according to claim 11 further comprising supplying air above the dividing elements to provide air in the pyrolysis chamber.

13. A method according to claim 11 or claim 12 wherein the waste is moistened with water or steam.

14. A method of burning waste substantially as described herein with reference to the accompanying drawing.

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1566763 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

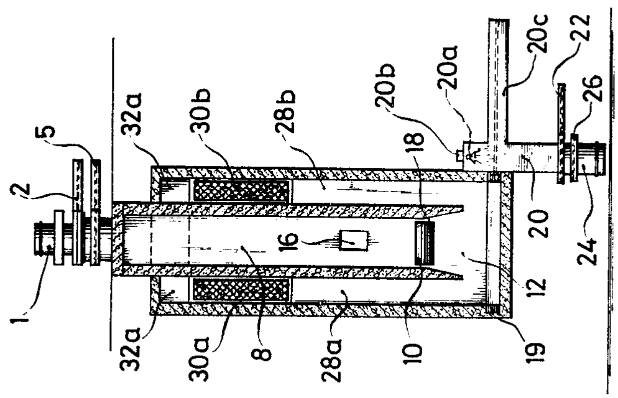

FIG. 2

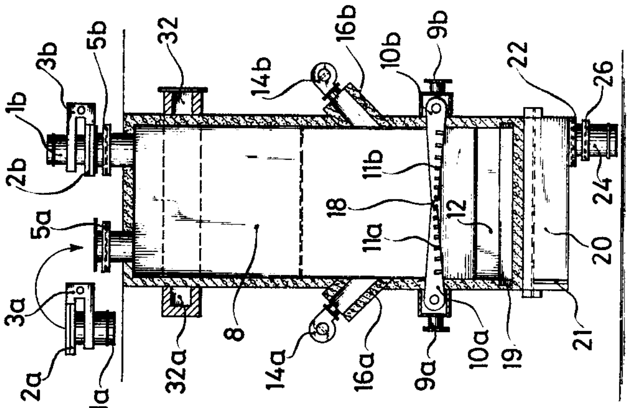

FIG. 1