

PATENT SPECIFICATION

(11) 1266405

DRAWINGS ATTACHED

1266405

- (21) Application No. 15023/69 (22) Filed 21 March 1969
 (31) Convention Application No. 18808 (32) Filed 23 March 1968 in
 (33) Japan (JA)
 (45) Complete Specification published 8 March 1972
 (51) International Classification F 23 g 7/00
 (52) Index at acceptance F4B A17



(54) SLUDGE TREATMENT

(71) We, KURITA WATER INDUSTRIES LIMITED, a Japanese body corporate of No. 1, 3-chome, Koraibashi, Higashi-ku, Osaka-shi, Japan, 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:—

The present invention relates to methods and apparatus for the incineration of wet organic sludge such as is produced in large quantities by waste treatment.

Where there are facilities for domestic and/or industrial waste treatment, a voluminous production of sludge, containing a high percentage of water, is inevitable and it is difficult to convert this sludge into an easily disposable material through further treatment. For instance, activated sludge or digested sludge are difficult to filter or dehydrate and even by subjection to treatment with a dewatering filter they cannot easily be sufficiently dewatered, and still normally contain about 80% of water.

The solid constituents of this sludge are substantially organic in nature and it has been proposed to dispose of them by means of incineration. However, incineration methods in the prior art have been designed to feed this sludge directly to an incinerator, and consequently, it has been difficult to burn it efficiently due to the large quantity of water still contained in it.

The present invention provides an incineration method for use in the disposal of wet organic sludge, which comprises heating said sludge, and by injecting the hot sludge under pressure into a combustion chamber which is at a lower pressure than the sludge being fed to the injection point, causing most of the water to be flashed off as vapour from the sludge as the sludge enters the chamber, leaving a particulate residue, and within said chamber incinerating that residue to burn off organic material therefrom leaving a final residue of ash.

When, for example, the sludge heated at

above 100°C and preferably at 1—5 kg/cm² gauge pressure is injected into a combustion chamber having a lower pressure, e.g. atmospheric pressure, most of the water content thereof is flashed off (lost as vapour immediately) because of the sudden drop in pressure within the chamber, this vapourisation causing the solid matter of sludge to be separated in almost a dried state. In such a state combustion is caused within the chamber by means of feeding in air which has been heated preliminarily, the floating dried fine particles of solid matter being reduced to ashes. (By "gauge pressure" is meant pressure in excess of atmospheric pressure).

At the beginning of this sludge incineration, there is a necessity for some supplementary fuel to be fed to the combustion chamber but once incineration has started, combustion continues by itself on account of the heat produced by the burning of the organic matter of the sludge. However, there may be some cases where such spontaneous incineration is hampered by the nature of the components of the sludge or by its remaining water content. In such an event, some supplementary fuel may be continually fed into the combustion chamber or a specific fuel like heavy oil may be preliminarily mixed with sludge to be fed for incineration to cope with this trouble.

The means for the heating of this sludge before injection into the chamber may utilize the waste gas resulting from the incineration of the sludge by installing the sludge feed pipe inside the flue (viz. smoke duct) and/or installing the sludge feed pipe inside the combustion chamber, so as to heat the sludge within this pipe by utilizing the heat of the combustion gas.

Moreover, the efficiency of combustion can be further enhanced by installing a packed bed of refractories inside the combustion chamber to catch the solid matter contained in the sludge to facilitate the incineration. To be more precise, the combustion chamber may be provided with a packed bed contain-

ing lumps of refractories, e.g. carborundum and the sludge may be injected in such a position that the dried or nearly dried solid matter thereof falls upon and adheres to the bed of refractories and is there reduced to ashes, the ashes then falling down in a melted state. With a packed bed of refractories inside the combustion chamber heated air fed into the chamber can be caused to pass at high velocity between the lumps of refractory material and fine particles of solid matter which adhere to the surface of these lumps of refractories are rapidly incinerated.

The combustion temperature is preferably regulated to be higher than the melting temperature of the ashes, and the surface of the refractories becomes covered with molten clinker which helps to retain fine particles of solid matter falling onto the refractory bed. The clinker gradually falls down to the bottom of the combustion chamber, and is discharged therefrom.

When a heated refractory bed is present the final dehydration of the particles which remain after flashing off most of the water and which are dispersed in the combustion chamber and fall on to the hot refractory bed, may occur at the surface of that bed and be followed there by the incineration of the dry particles. As a result, the total time required for converting wet sludge into dry ash can be reduced and the efficiency of combustion be enhanced. As the melting temperature of the ash resulting from the incineration of the sludge is relatively low, it is possible to melt the ash by maintaining the temperature of the packed bed of refractories at 1,400°C or thereabout, and there is no difficulty in finding suitable refractory material which will not be damaged by the ash at such temperature.

Embodiments of apparatus according to the invention will now be described by way of example together with examples of the method with reference to the accompanying diagrammatic drawings in which:—

Fig. 1 shows a vertical sectional view of one apparatus for incinerating sludge and

Fig. 2 shows a vertical sectional view of a second apparatus where the combustion chamber is provided with a packed bed of refractories.

Referring to Figure 1, an incinerator 1 is provided with a combustion chamber 2 therein and is designed to effect combustion of sludge under pressure which approximates to the atmospheric pressure. (It will commonly be somewhat less than atmospheric during operation of the plant owing to the draught of the combustion gas escaping through a flue 4 into the chimney stack 16). A sludge heating duct 3 which penetrates a side wall of the incinerator 1 and passes through the flue 4, has a nozzle 5 opening into the upper part of the combustion

chamber 2. Within the sludge heating duct 3 is a screw-feeder 6. The sludge heating duct 3 is connected with the sludge feeding duct 8 and the heavy oil feeding duct 9 through the medium of the pressure feeder 7. Further, in Fig. 1 there is provided an auxiliary fuel oil burner nozzle 10, a gate 11, a combustion air inlet 12, an ash pit 13, an air preheater 14, and a dust catcher 15.

Sludge is fed to the sludge heating duct 3 from the sludge feeding duct 8 through the medium of the pressure feeder 7. At the same time, heavy oil is fed through the heavy oil feeding duct 9 to be mixed with sludge, as required by the operating conditions. The sludge heating duct 3 which opens into the combustion chamber only through the nozzle 5 is heated by combustion gas passing through the flue 4. To prevent adhesion of scale to the interior of the sludge heating duct 3 and to stir the sludge and smooth the movement thereof, the screw feeder 6 is driven. Preferably the sludge is heated to 120—150°C within duct 3 and fed at 1 to 5 kg/cm² gauge pressure to the nozzle 5 whence it is injected into the combustion chamber 2. The sudden decrease in pressure on passing into chamber 2 causes most of the water in the hot sludge to vapourise away therefrom instantaneously and flow into the flue 4 together with combustion gases, while solid matter contained in the sludge descends in a dried state and burns while floating.

In order to begin the combustion, supplementary fuel is burnt for ignition purpose by way of the auxiliary burner 10. Once combustion has started, the necessity of further employment of supplementary fuel depends on the nature or quality of sludge to be incinerated, but, in practice, it may be concurrently employed for the purpose of expediting combustion. Combustion is brought about by feeding air preliminarily heated by means of the air preheater 14 into the incinerator from the combustion air inlet 12 by way of a specific duct which is not shown in the present figure. During this starting up operation, unburnt sludge containing carbonaceous residue in a relatively high proportion may accumulate on the grate 11 but is soon reduced to ashes by the blast of heated air and descends into the ash pit 13. Combustion gas at a high temperature, generated in the combustion chamber 2, is discharged into the atmosphere through the air preheater 14, dust catcher 15, and chimney stack 16 in order, after it has imparted its heat to the incoming sludge by way of the sludge heating duct 3.

Detection of the pressure within the sludge heating duct 3 is carried out and, based on the resultant data, the drive of the pressure feeder 7 is so controlled as to keep that pressure substantially constant. When the pressure in the sludge heating duct has been set

to be 1 the sludge temperature. When he be fed, smooth content of the combustion sludge is

Fig. 2 for use combustion a packed an incineration chamber which material to generally as explained this connection with a 3.

The purpose of the water-cooled the packing exhaust connecting

The exhaust nozzle 8 in the provided a means of

11, a 13, a flue provided in chamber connected

The outlet condition. conveyor 16

Hot inlet 17 fed in bed 3 a from the

4. The air inlet shown heated is heated the chamber opening thence the sludge means

sludge ing due to the 4 and the screw

Prefer

duct 3		to be 1 kg/cm ² gauge, the water content of	bed of refractories is heated up to about
duct		the sludge readily turns into vapour when the	1,400°C and sludge is brought to a gauge
ough		temperature of the sludge exceeds 120°C.	pressure of 1—5 kg/cm ² and a tempera-
ther, 70	5	When heavy oil is mixed with the sludge to	ture of 120—150°C within the sludge heat-
fuel		be fed, movement of the sludge becomes	ing duct 4 and thereafter forced through
stion		smooth and efficiency, flashing off of water	nozzle 8 into the combustion chamber 2, a
ater		content from the sludge is brought about, and	sudden decrease in pressure when passing into
		the combustion of the organic matter in the	chamber 2 causes most of the water in the
		sludge is expedited.	sludge to vapourise away instantaneously and
duct 75	10	Fig. 2 illustrated an apparatus designed	flow through the grate 5, opening 6 and
the		for use in incinerating sludge, comprising a	smoke box 7 into the flue 14 together with
the		combustion chamber which is provided with	combustion gas, while solid matters contained
heavy		a packed bed of refractory material. Inside	in the sludge descends in a dried and pul-
edge,		an incinerator 1, there is installed a combus-	verized state and adheres to packed bed 3
The 80	15	tion chamber 2 the internal pressure of	to burn. The combustion gas contributes some
the		which may be so maintained as to approxi-	of its heat while flowing through the air
nozzle		mate to the atmospheric pressure, (being	preheater 13 and past the sludge heating duct
ough		generally somewhat less owing to the draft,	4, enters the flue 14 where dust is removed
e to		as explained in connection with Figure 1)	by the dust catcher 15, and is exhausted there-
and 85	20	this combustion chamber 2 being equipped	after. The ashes drop in a melted state onto
ment		with a bed packed with refractory material	the conveyor 19 through the outlet 18 and
er-		3.	are discharged.
with-		The packed bed 3 is installed in the middle	As described in connection with Figure 1,
ange		of the combustion chamber 2 by use of a	drive of the pressure feeder 7 is controlled
ected 90	25	water-cooled grate 5, and the part beneath	according to the pressure detected in the
iden		the packed bed 3 opens into a neighbouring	sludge heating duct 4 to keep that pressure
amber		exhaust chamber 7 by way of the intercon-	substantially constant. When the pressure in
edge		necting opening 6.	the sludge heating tube has been set to 1
usly 95	30	The sludge heating duct 4 penetrates the	kg/cm ² gauge pressure the water content of
om-		exhaust chamber 7, and is equipped with a	the sludge readily turns into vapour when the
ined		nozzle 8 which opens above the bed 3. With-	temperature of the sludge exceeds 120°C.
and		in the sludge heating duct 4, there is pro-	When heavy oil is mixed with sludge to be
		vided a screw feeder 9 which is driven by	fed, movement of sludge becomes smooth,
ple-		means of a motor 10. A sludge feeding duct	efficient separation of water content from
by 100	35	11, a pressure feeder 12, an air preheater	sludge is brought about, and combustion of
om-		13, a flue 14, and a dust catcher 15 are also	sludge is expedited.
ends		provided. An auxiliary burner 16 is pro-	The apparatus, whether or not of the kind
in-		vided in the upper part of the combustion	having a refractory bed, preferably includes
cur-	105	chamber 2, said chamber being also con-	means for continuously detecting the pressure
edit-		nected with a combustion air inlet 17.	in the sludge heating duct and means for con-
out	40	The bottom of chamber 2 has a clinker	trolling the pressure feeder to that duct in
ans		outlet 18 and is kept in a water-sealed	accordance with the pressure so detected so
ator		condition. Beneath the outlet is provided a con-	to ensure that the pressure in the duct is
way 110	45	veyor 19.	greater than in the combustion chamber.
in		Hot air is fed through the combustion air	Contrary to the large combustion chambers
up		inlet 17 and causes the burning of the fuel	required by previous methods, because of the
car-		fed in at the auxiliary burner 16 to heat the	considerable length of time necessary for the
por-		bed 3 and at the same time the sludge issuing	dehydration of sludge by these methods, the
t is 115	50	from the nozzle 8 of the sludge heating duct	combustion chamber according to the present
ted		4. The hot air is supplied to the combustion	invention may be relatively small on account
om-		air inlet 17 by way of a tube (which is not	of its high efficiency of combustion.
ted		shown in the present drawing), after being	Owing to the efficiency of the method,
ged		heated by the air preheater 13 which in turn	through put of the apparatus, especially that
ater 120	55	is heated by combustion gas. This passes from	form having a packed bed of refractories, is
16		the chamber 2, through the grate 5, and the	high.
to		opening 6 into the exhaust chamber 7 and	The ashes resulting from combustion are
dge		thence into the flue 14, on its way heating	so thoroughly melted that very little free ash
		the sludge heating duct 4. Sludge is fed by	escapes into the air to cause a nuisance.
dge 125	60	means of the pressure feeder 12 from the	Moreover, the ash flows out in the form
on		sludge feeding duct 11 to the sludge heat-	of molten clinker which can conveniently be
ure		ing duct 4. To prevent adhesion of scale	used in manufacturing secondary products
hat		to the interior of the sludge heating duct	(e.g. blocks or framework materials). Specific
es-		4 and to smooth the movement of the sludge,	examples of the method of the invention are
set 130	65	the screw feeder 9 is driven.	now given.
		Preferably with this apparatus the packed	

EXAMPLE 1

Incineration was conducted by means of the apparatus shown in Fig. 1 while feeding thereto, at the rate of 50 kg/h, sludge turned out by waste treatment. The sludge contained water, averaging 80%, thereof, together with solid matter comprising combustibles to the extent of 50% thereof. In this case, heavy oil was concurrently fed at the rate of 0.46 l/h. The pressure in the sludge heating duct was maintained at 1 kg/cm² gauge and sludge therein was heated up to 120°C. The hot sludge was continuously injected through the nozzle into the combustion chamber to effect the incineration. By way of the auxiliary burner, light oil was burnt at the rate of 1.5 l/h, while air preheated at 100–200°C was sent into the combustion chamber through the combustion air inlet, and the internal temperature in that chamber was maintained at 800°C to effect combustion. The heat load within the combustion chamber was 130,000 Kcal/m³h and the excess air factor therein was 1.2, the combustion of sludge was performed satisfactorily.

EXAMPLE 2

Incineration was conducted by means of the apparatus shown in Fig. 2 while feeding thereto at the rate of 100–150 kg/h, sludge turned out by waste treatment, this sludge containing water, averaging 75–80%, thereof, together with solid matter comprising combustibles to the extent of 50% thereof. In this case, combustion was performed by keeping the nozzle jet pressure in the range of 0.2–0.7 kg/cm² gauge and the nozzle jet temperature in the range of 103–111°C. In addition, by means of the auxiliary burner, light oil was burnt at the rate of 10–20 l/h. For the packed bed with refractories, carborundum with a grain size of 3–5 cm was employed to form a bed of 0.2 m thick. The grate was 0.09 m² in area. The heat release efficiency of the packed bed with refractories was 1.2–2.0×10⁷ Kcal/m³h, the heat release efficiency per unit area of grate was 3.0–5.0×10⁶ Kcal/m²h, the maximum temperature of the packed bed was 1,500°C, and the quantity of flying dusts was 1–2 g/m³.

WHAT WE CLAIM IS:—

1. An incineration method for use in the disposal of wet organic sludge, which comprises heating said sludge, and by injecting the hot sludge under pressure into a com-

bustion chamber which is at a lower pressure than the sludge being fed to the injection point, causing most of the water to be flashed off as vapour from the sludge as the sludge enters the chamber, leaving a particulate residue, and within said chamber incinerating that residue to burn off organic material therefrom leaving a final residue of ash.

2. A method of incinerating sludge as claimed in claim 1, in which the combustion chamber has a packed bed of refractories, and the residual solid matters are caused to adhere onto the packed bed of refractories and are burnt down thereby.

3. A method of incinerating sludge as claimed in any one of claims 1 and 2 wherein the sludge prior to introduction into the combustion chamber is preheated by heat imparted by the combustion gas.

4. A method as claimed in claim 1, 2 or 3 wherein the sludge is injected at a temperature from 100 to 150°C.

5. A method as claimed in claim 1, 2 or 3 wherein the pressure of sludge at the injection point is 1 to 5 kg/cm² gauge pressure.

6. A method of sludge incineration substantially as described in Example 1 or 2.

7. An apparatus for incinerating sludge comprising: a combustion chamber having an auxiliary burner, a combustion-air inlet, as well as a packed bed of refractory material and below said bed an outlet for melted ashes, an exhaust chamber for combustion gases, said chamber being equipped with an air preheater and connecting with the combustion chamber by way of one opening and with a flue by another opening, a sludge heating duct equipped with a screw feeder and arranged to penetrate the exhaust chamber and to open into the combustion chamber and means, including a pressure feeder, for causing sludge to be treated to pass through the sludge heating duct into the combustion chamber under a pressure greater than that obtaining in said chamber, so that most of the water is flashed off as vapour from the sludge as the sludge enters the combustion chamber.

8. An apparatus according to claim 7 comprising means for continuously detecting the pressure of the sludge being fed to the injection point and means for controlling the action of the pressure feeder in accordance with the pressure so detected to ensure that said pressure remains higher than the pressure in the combustion chamber.

9. An apparatus substantially as shown in Figure 1.

10. An apparatus substantially as shown in Figure 2.

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EXAMPLE 1

Incineration was conducted by means of the apparatus shown in Fig. 1 while feeding thereto, at the rate of 50 kg/h, sludge turned out by waste treatment. The sludge contained water, averaging 80% thereof, together with solid matter comprising combustibles to the extent of 50% thereof. In this case, heavy oil was concurrently fed at the rate of 0.46 l/h. The pressure in the sludge heating duct was maintained at 1 kg/cm² gauge and sludge therein was heated up to 120°C. The hot sludge was continuously injected through the nozzle into the combustion chamber to effect the incineration. By way of the auxiliary burner, light oil was burnt at the rate of 1.5 l/h, while air preheated at 100–200°C was sent into the combustion chamber through the combustion air inlet, and the internal temperature in that chamber was maintained at 800°C to effect combustion. The heat load within the combustion chamber was 130,000 Kcal/m³h and the excess air factor therein was 1.2, the combustion of sludge was performed satisfactorily.

EXAMPLE 2

Incineration was conducted by means of the apparatus shown in Fig. 2 while feeding thereto at the rate of 100–150 kg/h, sludge turned out by waste treatment, this sludge containing water, averaging 75–80%, thereof, together with solid matter comprising combustibles to the extent of 50% thereof. In this case, combustion was performed by keeping the nozzle jet pressure in the range of 0.2–0.7 kg/cm² gauge and the nozzle jet temperature in the range of 103–111°C. In addition, by means of the auxiliary burner, light oil was burnt at the rate of 10–20 l/h. For the packed bed with refractories, carborundum with a grain size of 3–5 cm was employed to form a bed of 0.2 m thick. The grate was 0.09 m² in area. The heat release efficiency of the packed bed with refractories was 1.2–2.0×10⁷ Kcal/m²h, the heat release efficiency per unit area of grate was 3.0–5.0×10⁶ Kcal/m²h, the maximum temperature of the packed bed was 1,500°C, and the quantity of flying dusts was 1–2 g/m³.

WHAT WE CLAIM IS:—

1. An incineration method for use in the disposal of wet organic sludge, which comprises heating said sludge, and by injecting the hot sludge under pressure into a com-

bustion chamber which is at a lower pressure than the sludge being fed to the injection point, causing most of the water to be flashed off as vapour from the sludge as the sludge enters the chamber, leaving a particulate residue, and within said chamber incinerating that residue to burn off organic material therefrom leaving a final residue of ash.

2. A method of incinerating sludge as claimed in claim 1, in which the combustion chamber has a packed bed of refractories, and the residual solid matters are caused to adhere onto the packed bed of refractories and are burnt down thereby.

3. A method of incinerating sludge as claimed in any one of claims 1 and 2 wherein the sludge prior to introduction into the combustion chamber is preheated by heat imparted by the combustion gas.

4. A method as claimed in claim 1, 2 or 3 wherein the sludge is injected at a temperature from 100 to 150°C.

5. A method as claimed in claim 1, 2 or 3 wherein the pressure of sludge at the injection point is 1 to 5 kg/cm² gauge pressure.

6. A method of sludge incineration substantially as described in Example 1 or 2.

7. An apparatus for incinerating sludge comprising: a combustion chamber having an auxiliary burner, a combustion-air inlet, as well as a packed bed of refractory material and below said bed an outlet for melted ashes, an exhaust chamber for combustion gases, said chamber being equipped with an air preheater and connecting with the combustion chamber by way of one opening and with a flue by another opening, a sludge heating duct equipped with a screw feeder and arranged to penetrate the exhaust chamber and to open into the combustion chamber and means, including a pressure feeder, for causing sludge to be treated to pass through the sludge heating duct into the combustion chamber under a pressure greater than that obtaining in said chamber, so that most of the water is flashed off as vapour from the sludge as the sludge enters the combustion chamber.

8. An apparatus according to claim 7 comprising means for continuously detecting the pressure of the sludge being fed to the injection point and means for controlling the action of the pressure feeder in accordance with the pressure so detected to ensure that said pressure remains higher than the pressure in the combustion chamber.

9. An apparatus substantially as shown in Fig. 1.

10. A substance to be incinerated.



9. An apparatus for sludge incineration substantially as herein described with reference to Figure 1 of the accompanying drawing.

- 5 10. An apparatus for sludge incineration substantially as herein described with reference to Figure 2 of the accompanying drawing.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1972.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.

