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[54] **PROCESS FOR INCINERATING SLURRY AND APPARATUS THEREFOR**

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[52] **U.S. Cl.** ..... **110/8 C,** 110/15

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[58] **Field of Search** ..... 110/8 R, 8 C, 15, 18 R, 110/18 C

[56] **References Cited**

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[57] **ABSTRACT**

Partially dried slurry containing organic matter and ash-forming components are dried by means of the combustion heat generated in subsequent combustion of the dried slurry. The dried slurry is transferred in powder form into an incinerator wherein it is burned in suspended condition. The temperature of the incinerator is kept above the melting point of the ash formed therein. Where the melting point of the ash is high, it is lowered by the addition of salts of sodium or calcium prior to incineration. The incinerated ash in fused condition is separated from the hot combustion gases which then pass on to the dryer.

19 Claims, 2 Drawing Figures

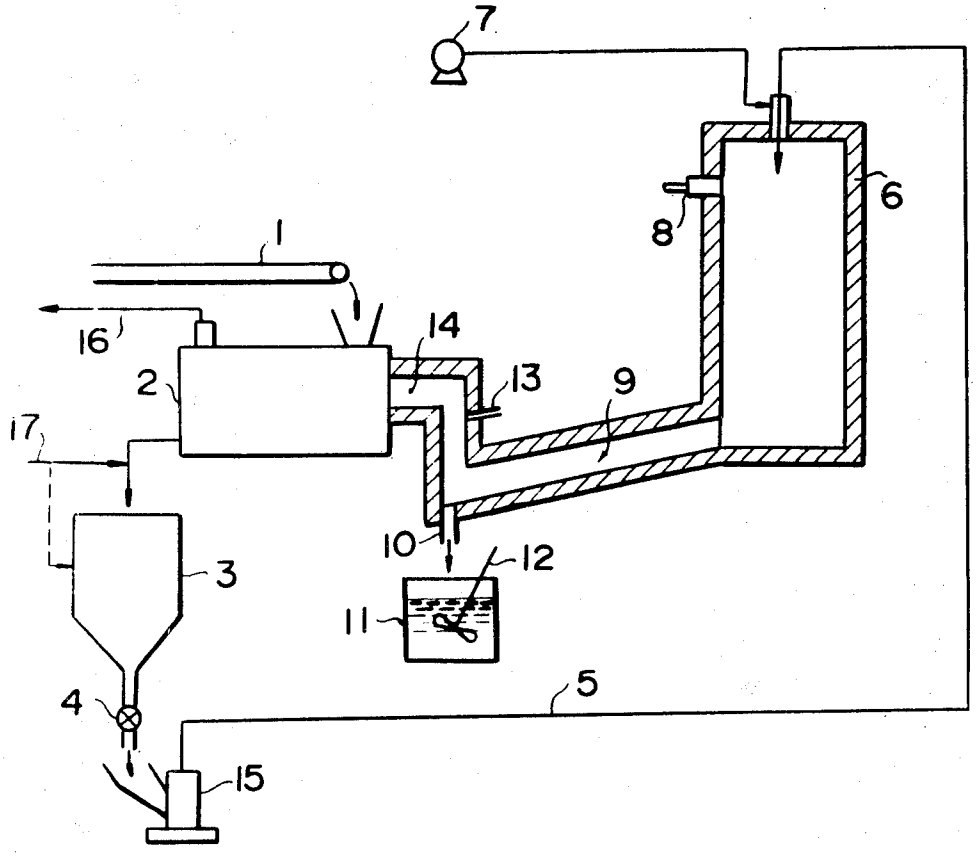


FIG - 1

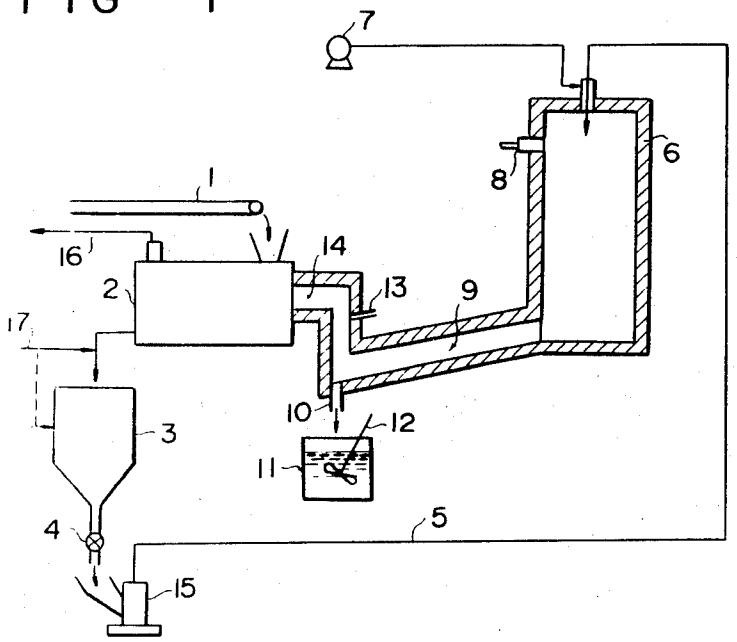
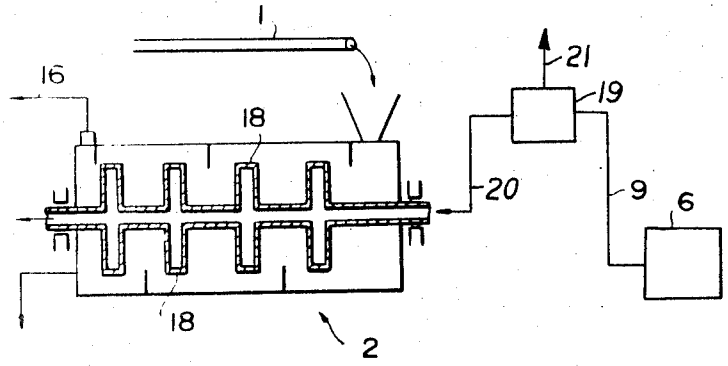


FIG - 2



PROCESS FOR INCINERATING SLURRY AND APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

The treatment of slurry containing organic materials such as sewage and human waste is becoming of increasing importance due to the contamination of rivers, harbors and even the ocean. A number of treatment methods have been proposed but no completely satisfactory method has yet been devised. Although, in general, it is not difficult to incinerate slurry, the problems associated with the incineration, such as complete drying of the slurry, handling of the ash produced, and removal of all objectionable odor as well as ash fines have not been solved. Further, where the ash produced during incineration is in finely divided form, scattering of the ash occurs during storage and transportation. Moreover, since the ash generally contains some organic material, applications for same cannot be found. When water is sprinkled on the ash, it becomes clay-like and even more difficult to handle.

SUMMARY OF THE INVENTION

Slurry from a sedimentation pond or the like, where said slurry contains organic matter, inorganic matter and a high content of water is filtered and partially dehydrated by conventional means. The resulting cake is introduced into a dryer and dried by means of the heat produced in the combustion of the organic material in said cake. The dried filter-cake is pulverized, transported to an incinerator by means of an air conveyor, or the like, and is introduced in finely dispersed form into the incinerator wherein it is burned in suspended condition. The temperature of the incinerator is maintained above the melting point of the ash formed during combustion of the slurry. Where the melting point of the ash is high, it is lowered by adding salts of sodium or calcium to the dried slurry prior to transporting to the incinerator. The ash is separated from the flue gas leaving the incinerator proximate the bottom thereof and the flue gas is lead to the dryer where it dries the incoming slurry. The fused ash is withdrawn from the flue in molten form and may be dropped into water to be formed into small particles or may be solidified into cakes or blocks.

Accordingly, an object of the present invention is to provide an improved process for the treatment of slurry containing sewage, organic waste and inorganic components wherein the final product consists of ash in granular or block form and combustion gases free of ash fines and malodorous components.

Another object of the present invention is to provide an improved process for the incineration of slurry containing organic and inorganic waste products wherein the heat of combustion of said organic products is used for drying incoming slurry.

A further object of the present invention is to provide an improved process for incineration of slurry containing organic and inorganic matter wherein calcium or sodium salts may be added to lower the melting point of ash formed during incineration.

A significant object of the present invention is to provide improved apparatus for the incineration of slurry containing sewage and inorganic matter wherein the heat of combustion of organic components is used for drying of said slurry in preparation for incineration and wherein ash produced during incineration is removed in fused form.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combination of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWING

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawing, in which:

FIG. **1** is a diagrammatic view of an apparatus in accordance with the present invention; and

FIG. **2** is an embodiment thereof comprising an indirect dryer.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The feed to the apparatus of the present invention is assumed to be a filter-cake obtained by filtering and dehydrating slurry from a sedimentation pond or the like. The filter-cake contains from 60 to 80 percent of water and is introduced by means of conveyor **1** into drier **2** in which the water is removed by direct or indirect contact with the hot gases from incinerator **6.** The dried product leaving dryer **2** is pulverized and may be stored in storage tank **3.**

Dust contained in the exhaust gas from drier **2** is collected by a cyclone separator (not shown). The exhaust gas from the cyclone is washed with water and water contaminated with dust is fed back to the sedimentation pond.

The powdered slurry is removed from storage tank **3** through valve **4** and fed into injector **15** which fluidizes the slurry in an air stream and conveys the slurry through air conveyor **5** to incinerator **6.** Auxiliary air for combustion in incinerator **6** is supplied by blower **7.** For preheating the incinerator at the start-up of operation, or where additional heat is needed, fuel may be injected at burner **8.**

Where the melting point of the ash formed in the combustion of the slurry is high, the melting point of the ash may be lowered by adding a small amount of salts of sodium or calcium to the dried powdery slurry stored in the storage tank **3.** Suitable materials are salts of sodium or calcium such as calcium oxide, calcium carbonate, slaked lime, sodium sulfate, etc. Specifically, where the ash is primarily silicon dioxide, the melting point thereof may be between 1,500° and 1,700° C. In order to be able to remove the silicon dioxide in fused condition, it is necessary to lower the melting point thereof, because such temperatures are destructive to the walls of the incinerator and, in addition, difficult to achieve. Therefore, it is desirable to mix alkali with the dried powdery slurry so that the product is essentially calcium silicate or sodium silicate. Where slaked lime is mixed with slurry during the filtration process prior to introduction to the apparatus, addition of calcium or sodium oxides or salts may be omitted.

When the dried slurry with or without added alkaline materials is jetted into the interior of the incinerator which has been pre-heated to 1,200° C or above, ignition of organic materials occurs immediately, since the ignition temperature of such organic matter is generally no higher than 500° C. In addition, the feed to the incinerator generally contains no more than about 1 percent of water. Consequently, it is generally possible to reach a temperature as high as 1,300° C or higher without the addition of auxiliary fuel. For optimum operation of the incinerator, the amount of slurry and air should be adjusted so that the exhaust gases leaving the incinerator contain no more than 5 percent of residual oxygen on a volume basis.

The combustion products and the ash formed in the incinerator **6** leave same through a flue **9** positioned proximate the bottom of incinerator **6.** The flue **9** slopes downwardly and has an opening **10** at the lowest point thereof through which the molten ash may be dropped into a tank **11** containing water kept in motion by an agitator **12.** Alternatively, the molten ash may be dropped on to a cooled surface (not shown) and allowed to solidify in the form of blocks or a cake.

Separation of the molten ash from the combustion gases leaving incinerator **6** is essentially complete due to the turbulence of the gas flowing through flue **9** as a result of which the droplets of molten ash come in contact with the walls and are thereby removed from the stream.

The hot gases are lead by flue **9** to duct **14** and thereby into dryer **2.** At a point between flue **9** and duct **14** a sensor for determining oxygen content of the flue gas may be inserted, or, alternatively, **13** may be an opening through which flue gas samples can be removed for analysis as to oxygen content. Based on the oxygen content of the flue gas, blower **7** and injector **15** can be separately or simultaneously adjusted to keep the oxygen content of the flue gas at or below 5 percent by volume.

The salt or oxide used to depress the melting point of the silica present in the slurry may be added to the stream of dried material leaving dryer **2** and approaching storage tank **3,** as indicated by the arrow bearing the reference numeral **17.** Alternatively, the added oxide or salt can be introduced directly into tank **3** as indicated by the dashed line.

In the drying of the slurry cake by flue gas in dryer **2,** the dryer may be damaged as the result of the high temperature of the gas. This difficulty may be avoided by transferring the flue gas sensible heat to water which carries the heat as latent heat of vaporization. An arrangement designed for this purpose is shown in FIG. **2** where incinerator **6** is indicated schematically together with a waste heat boiler **19** wherein the flue gases passing through flue **9** generate steam which enters indirect dryer **18** through conduit **20.** Cooled flue gas leaves boiler **19** through stack **21.**

The drying chamber in this case, provides for indirect drying, namely, the flue gas or steam passes through the interior of rotary disc heat exchanger **18,** but it should be noted that steam generated by flue gas can also be used for direct drying. As an example of the improved performance obtained from the indirect dryer system, when a dryer of the direct heating type was employed, about 1.4m^3 (approximately 1.9kg) of non-condensible exhaust gas was produced per kilogram of steam. On the other hand, when a dryer of the indirect heating type was substituted, only 0.05m^3 (approximately 0.07kg) of exhaust gas was generated per kilogram of steam. The exhaust gas from either direct or indirect drying was virtually odorless.

Following is an example of performance obtained with apparatus in accordance with the present invention. Slurry obtained from a sedimentation pond containing organic matter was filtered and dehydrated by conventional means to obtain a slurry cake containing 70 percent water. The cake was fed to dryer **2** by means of conveyor **1** at a rate of 200kg/h. The dried slurry leaving dryer **2** weighed 60kg and contained less than 1 percent of water. The dry slurry was stored in storage tank **3** and slaked lime was added thereto at the rate of 20kg/h. The dry, powdery slurry was removed from the bottom of the storage tank **3** through rotary valve **4** and fed to injector **15.** From injector **15,** the dried slurry was conveyed through air conveyor **5** to the top of incinerator **6.** The rate of feed was 80kg/h carried by air supplied at a rate of 60m^3/h. The caloric content of the slurry was independently determined to be 3,000kcal/kg.

The incinerator **6** was a vertical cylinder measuring 560mm in internal diameter and 1,500mm in internal height. The incinerator was thermally insulated to decrease heat radiation.

For combustion of the slurry, secondary air was supplied at the rate of 3.5m^3 per kg of slurry, the secondary air being supplied by blower **7.**

The incinerator **6** had been pre-heated to somewhat above 1,200° C by use of preheating burner **8.** As soon as the feed of slurry started, the use of the preheating burner **8** became unnecessary because the internal temperature of the incinerator quickly reached 1,300° C and levelled off between 1,300° and 1,350° C. Combustion of the slurry took place as the slurry was in transit from the top of the incinerator to the bottom.

Subsequent to incineration, exhaust gases and fused ash flowed out of the incinerator **6** through flue **9.** The fused ash flowed through opening **10** dropwise into tank **11** disposed below opening **10.** The fused ash solidified to form granules having a diameter between 2 and 3 mm. The purpose of the agitator is to improve heat transfer and to avoid local generation of steam which can be violent. Actually, agitation of the water in the tank **11** is not necessary when incineration is carried out on so small a scale as in the present example. For a large scale operation, a trough with water flowing therethrough would be preferable.

Further downstream in the flue, exhaust gas was sampled through sampling hole **13** and based on the analysis of the flue gas the rate of feed of secondary air from blower **7** was adjusted to maintain the oxygen content of the flue gas at 5 percent or less. As is evident, control of the blower can be made automatic.

Finally, the hot flue gas was passed through drying chamber **2** to remove water from the wet cake. As indicated above, it is preferable that the hot flue gas be used to generate steam in a heat exchanger and that the drying be carried out by means of the steam, the rotary disc type **18** shown in FIG. **2** being particularly suitable for the purpose.

Depending on the caloric content of the cake to be incinerated, the burning of auxiliary fuel may be necessary when the operation is carried out on a small scale. For large scale operation, the ratio of surface to volume in the incinerator is so much smaller than in the present

case that auxiliary burner 8 is needed only for preheating.

Experiments were carried out to determine the amount of added oxide or salt necessary to lower the melting point of the silica in the slurry. In carrying out the experiment, 600g of CaO, $Ca(OH)_2$ Na_2SO_4 and $CaCO_3$ were respectively added to 1kg samples of ash from the combustion of sewage slurry. The melting point of the ash by itself was 1,450° C; the melting points of the slurries containing the above additives were respectively 1,290° C, 1,250° C, 1,220° C and 1,320° C. These results show that the melting point of the ash contained in the slurry can be lowered effectively by the addition of sodium or calcium oxides or salts. This is a particularly important feature of the present invention since it eliminates the need for removal of ash and transportation of same away from the system encountered in conventional apparatus. Moreover, the caked product formed by means of the present process is non-powdery, is easily transported without scattering powder, and is useful for the repair of roads.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above process and in the constructions set forth without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A process for the incineration of slurry containing organic matter, comprising the steps of passing incoming slurry through a drying chamber, burning said dried slurry in dispersed condition to an ash in an incinerator, the temperature of combustion being controlled to be above the melting point of the ash formed during said incineration, passing the hot combustion gases and molten ash from said incinerator through a downwardly sloping common flue connected to said incinerator proximate the bottom thereof, said fluid having a lowest region, separating said ash in molten condition from the hot combustion gases at said lowest region and transferring the heat from said hot combustion gases to incoming slurry in said drying chamber.

2. The process as defined in claim **1** wherein an inorganic compound is added to said slurry prior to incineration, said compound being of such a type as to lower the melting point of said ash.

3. The process as defined in claim **2** wherein said inorganic compound is selected from the group consisting of CaO,$Ca(OH)_2$, $CaCO_3$ and Na_2SO_4.

4. The process as defined in claim **1** wherein said hot combustion products are brought into direct contact with said incoming slurry.

5. The process as defined in claim **1** wherein said drying chamber is of the indirect drying type.

6. The process as defined in claim **1** wherein the quantity of air supplied to said incinerator is controlled to keep the residual oxygen content in the combustion exhaust gas at 5 percent or less by volume.

7. The process as defined in claim **1** wherein heat is added to said incinerator by combustion of auxiliary fuel.

8. The process as defined in claim **1** wherein the heat in said flue gas is transferred to water, generating steam, and said steam is introduced into said dryer to dry said slurry.

9. The process as defined in claim **1** wherein said fused slurry in the form of small drops is brought into contact with water to form granules measuring 2 to 3mm in diameter.

10. The process as defined in claim **1** wherein said fused slurry is allowed to cool into block form.

11. An apparatus for incineration of slurry containing organic matter and ash-forming components, comprising a dryer for decreasing the moisture content of said slurry, an incinerator capable of operating at temperatures above the melting point of ash formed in said incinerator, means for conveying said slurry to said incinerator, a flue at the bottom of said incinerator for downwardly-leading hot combustion exhaust gas and molten slag toward said dryer for drying incoming slurry, said flue having a lowest region and an opening at said lowest region for separating fused ash from said hot combustion exhaust gas.

12. The apparatus as defined in claim **11,** further comprising means for adding calcium or sodium salts to said dried slurry prior to incineration in order to lower the melting point of ash formed during said incineration.

13. The apparatus as defined in claim **11** wherein the hot combustion exhaust gases from said incinerator come into direct contact with said slurry for drying same.

14. The apparatus as defined in claim **11** wherein said dryer is of the indirect type.

15. The apparatus as defined in claim **11** wherein said incinerator is provided with a burner for the combustion of auxiliary fuel.

16. The apparatus as defined in claim **11,** further comprising boiler means for transferring the heat in said hot combustion to water and conduit means for leading the steam generated in said boiler means to said dryer.

17. The apparatus as defined in claim **11,** further comprising means for separating fused ash from said hot combustion exhaust gas passing through said flue.

18. The apparatus as defined in claim **17** wherein a water tank is positioned beneath said opening for separating said fused ash for reception of said separated fused ash and converting same into granules measuring 2 to 3 mm in diameter.

19. The apparatus as defined in claim **11** further comprising sampling means for determining the oxygen content of said flue gas and means for controlling the air input to said incinerator chamber so as to maintain the oxygen content in said flue gas at 5 percent or lower.

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