METHOD AND APPARATUS FOR DISPOSING OF REFUSE

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ABSTRACT

An apparatus for disposal of refuse consists of three sections arranged in vertical sequence and communicating by means of ports which permit refuse to pass from the top chamber to the bottom chamber. The refuse is dried in the top chamber, gasified in the middle chamber and burned in the bottom chamber. Exhaust gases from the bottom chamber, in part, pass upward through downwardly moving refuse to effect gasification in the middle chamber and drying in the top chamber. Exhaust gases from the top chamber are treated to remove noxious and corrosive components prior to recycling to the apparatus and to venting. The method and apparatus are suitable for use with mixed refuse containing among other components, glass, metal and garbage.

10 Claims, 6 Drawing Figures
METHOD AND APPARATUS FOR DISPOSING OF REFUSE

BACKGROUND OF THE INVENTION

In general, refuse from community and from various types of industrial facilities vary widely in composition, and may include, for instance, sludge from sewage, garbage, plastic scraps, tires and other articles of rubber, scrap wood, oil-impregnated rags and refuse oils, all of which are organic, as well as concrete debris and scrap metal. The inflamables among these components range widely in heat of combustion from about 1,200 kcal/kg up to about 7,000 kcal/kg. Consequently, it has been necessary to use a variety of types of disposal facilities for handling each type of material. This is obviously uneconomical, taking into account such factors as the cost of sites, the cost of operation, the difficulty of the operating techniques involved, etc. Moreover, the various types of materials are mixed together in the refuse so that separation of the materials in accordance with the type of treatment necessary is prohibitively expensive.

It has not been possible to treat all of these types of materials by ordinary combustion methods because offensive odors have been generated as a result of imperfect combustion, the production of components which are extremely corrosive, particularly at high temperature, adherence of fly-ash and the presence of substantial amounts of imperfectly combusted components in the residual ash.

Disposal of ash also poses problems such as the scattering of ash dust by means of winds or fouling of water. Moreover, provision must be made for preventing corrosion and damage to the combustion equipment and instruments and to preventing pollution of the environment such as is caused by the gases resulting from the combustion of chlorinated organic materials. The increase in the quantity of scrap vinyl chloride resins is a factor here.

Conventionally, in the course of incineration, gasification is carried out by injecting air and steam prior to incineration. The objective is to convert organic materials from different sources into forms which will burn uniformly in the manner of coal, wood or charcoal; however, refuse varies so widely in properties that the reaction velocity of gasification also varies strongly. Consequently, the difficulty in effecting complete combustion without harm to the environment has been such as to make the incineration operation uneconomical in many cases.

SUMMARY OF THE INVENTION

The present invention provides an improved method for disposal of refuse comprising the successive steps of drying, gasifying and combustion, each step being carried out in a separate chamber. The three chambers are disposed in vertical sequence and communicate by means of ports which permit the refuse to travel downwards and permit exhaust gases to travel upwards. Gases venting from the drying chamber are first treated to remove noxious and corrosive components. Following this treatment a portion of the gas is recycled to the incineration apparatus. The remainder of the gas is stored for use as fuel or is vented. The portion of the gas which is recycled is split, part of the gas being injected into the combustion chamber for use as fuel and part being humidified and injected into the gasifying chamber to control the temperature thereof and to prevent combustion therein. The recycled gas is preheated prior to injection into the apparatus.

Accordingly, an object of this invention is to provide a method and apparatus for the complete incineration of mixed refuse without venting noxious or corrosive gases.

Another object of the invention is to enhance the overall heat efficiency of incineration while precluding pollution of the environment.

A further object of the invention is to improve the efficiency and simplify the apparatus for and the process of incineration of mixed refuse, thereby reducing the initial cost and the operational cost of incineration.

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 flow sheet of the process in accordance with the present invention;
FIG. 2 is an elevational view in cross section of the incineration apparatus; and
FIGS. 3 through 6 are elevational views of the incineration apparatus in partial cross section together with associated components.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the present invention, a disposal apparatus, generally designated by the reference numeral 12 comprises chambers 1, 2 and 3 in which drying, gasification and incineration are carried out continuously. The refuse to be treated, after having been broken down by pulverization is first fed into the drying chamber 1 wherein the refuse is maintained at a suitable temperature by means of the gas traveling upward from the chamber below in which gasification is carried out. The refuse is dewatered in chamber 1 until it is substantially dry. The refuse which is also preheated in the drying chamber 1 is passed continuously to the gasifying chamber 2 where it comes in contact with hot exhaust gas produced in the ensuing incineration step. The refuse is rapidly pyrolyzed by the exhaust gases and reaches ignition temperature, but ignition is prevented by the injection of high temperature air having a high humidity as will be described later. The humid air thus injected maintains the temperature at the optimum level for rapid gasification and carbonization of any combustible components present after which it travels upward through the drying section as described above.
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In the gasifying step, the volume and weight of the refuse are substantially decreased as a result of the gasifying of such volatile components as may be present, and of destructive distillation of organic materials.

In the ensuing combustion step in which the inner incineration process is completed, the refuse is subjected to high temperature combustion with the aid of injected oil, pre-heated blast air and recycled exhaust gas containing combustibles developed in the gasifying step.

The residue from the combustion step consists of ash and molten or partly-molten metals which are lead into a water-sealed granulator 4 in which the residue is cooled and granulated, after which it is released from the system.

The combustible gases produced in the gasifying step and utilized for drying may contain corrosive components such as chlorine or hydrogen chloride as the result of the presence of chlorinated organic materials in the refuse treated. Such gases, on leaving drying section 1 through port 24 are cooled in heat exchanger 5 and then guided into dephlegmator 6 where chlorine, hydrogen chloride and other corrosive components and other corrosive components and other corrosive components are dissolved in water. The components in solution may be separated and recovered as hydrochloric acid and chemical agents such as hypochlorites.

A portion of the thus-treated combustible gases is re-heated in heat exchanger 5 and recycled in part to the drying step and in part to the combustion step where it is utilized as auxiliary fuel. Surplus gases are stored in gas holder 7 for use as fuel or may be vented since they no longer contain offensive components.

Part of the exhaust gas produced in the combustion step rises into chamber 2 for effecting gasification and thence into chamber 1 to carry out drying. The major portion of the exhaust gas is guided through air preheater 8, a waste heat recovery apparatus 9 and a dust collector 10 after which it is released into the atmosphere through stack 11. The air pre-heated in air preheater 8 is in part fed into the combustion chamber 3 where it is gasified into the gasifying chamber after having been humidified in humidifier 26 where steam is mixed therewith.

The disposal apparatus 12 is provided with a refuse charging port 23 having dampers 21 and 22 and a waste gas exhaust port 24. Waste gas exhaust port 24 leads to heat exchanger 5 and dephlegmator 6. Drying section 1 has in its lower portion an input nozzle 25 through which heated gas is supplied from heat exchanger 5.

Gasifying section 2 is supplied with high-temperature, high-humidity air through input nozzle 26. Moisture in the form of steam is added to humidity adjuster 20 through input nozzle 19. A rotary conical grate 27 is provided at the bottom of incinerating chamber 3, and high-temperature blast air is supplied from below said grate through inlet 28. The combustion section also includes an auxiliary combustion burner 32 at which oil and fuel gases are burned and a waste gas exhausting port 33 through which the hot exhaust gases are lead to air preheater 8, supplied with air through inlet 18.

The upper peripheral wall 29 of combustion chamber 3 is shaped to reflect heat back to the combustion grate. The bottom of combustion chamber 3 is provided with a residue-exhausting port 30 leading to a water-sealed clinker tray 31.

The gasifying section 2, being of conical shape may be constructed to be rotatable. The objective is to control the rate at which refuse passes through the system.

The wall of the gasifying section 2 may be used as a heat exchanger to generate water vapor which is then mixed with the high-temperature air supplied through inlet port 26.

The refuse 13 which is to be treated is charged to the combustion equipment through charging port 23 by a crane 45 (FIGS. 3-6) or other means. The refuse is fed into drying chamber 1 through dampers 21 and 22 which are operated in sequence so that when either one of said dampers is open the other is closed.

Most of the exhaust gas produced in the combustion section 3 is vented through waste gas-exhausting port 33. After being utilized in preheating the combustion air being lead to the combustion section and the gasifying humid air being lead to the gasifying section, it is passed to heat recovery equipment 9, and dust collector 10 after which it rises through stack 11 to the atmosphere.

As stated above, part of the exhaust gas rises into reducing section 2 to accelerate the gasification reaction.

The inflammable gas produced in the course of the gasifying reaction in section 2 contains noxious substances such as sulfides, chlorides, other halogens, etc. which would be offensive if vented directly to the atmosphere and which are corrosive to equipment. Consequently, the inflammable gas, before passing through exhaust port 25 in drying section 1 is diluted with heated gas injected through nozzle 25; as previously described, this exhaust gas passes through heat exchanger 5 and back through conduit 15 after dephlegmation.

In the embodiment shown in FIG. 3, the incinerator is equipped with a swinging lattice bridge 34 and a pusher 35. The incinerator of FIG. 4 has a stepped stoker 36 and a pusher 35 while the embodiment of FIG. 5 has a rotary kiln 37 and a pusher 35. High temperature air is blasted into its lower high-temperature charging portion; the upper surrounding wall is constructed of refractory material, and the lower part is provided with clinker exhaust port 40 through which residue passes to ash tray 41 below. The combustion section is provided with an auxiliary burner 42 for oil fuel gas to effect complete combustion and with a waste gas exhausting port 43.

In the Figures are also shown stack 44, crane 45 for the charging of refuse, crane operators cabin 46, a tertiary air supply 47 (FIG. 3), a refuse pit 48 (FIGS. 3 and 4), a pusher 49, a damper 50 (FIGS. 3, 4 and 5) for adjusting furnace pressure and driving means 51 for rotating kiln 39 (FIG. 5).

In the embodiment of FIG. 6 an incineration system of steel and refractory has a refuse charging port 23, a drying section 1, a dry distillation section 52 for preheating and thermally decomposing dried refuse, a gasifying section 2 and a combustion section 3 in which complete incineration of the refuse takes place.

The refuse charging port 23 is provided with a lid 53 and a damper 54 operated in tandem as described with reference to FIG. 1.

The upper portion of drying section 1 is provided with an outlet 55 through which waste gas is guided. The lower portion of drying section 1 has an input noz-
ze 56 for the injection of heated gas to cooperate with rising waste gas in drying the refuse. To the lower portion of the dry distillation section 52 and the gasifying section 52 are connected respectively nozzles 57 and 58 for the injection of air, mixtures of air and steam, mixtures of air, oxygen and steam, or the like.

The gasifying section 2 is in the form of an inverse cone as shown in the Figure, and the circumferential wall thereof may be constructed so as to be rotatable and may be equipped with guiding blades. Also, in order to make certain that all of the refuse traversing the gasifying section is uniformly treated, a rotating cylindrical fire grate 59 having projections, or an overturning fire grate in the form of triangular pyramids may be provided. The axle of the fire grate is so constructed as to be protected by cooling so that it can serve for crushing residue and thereby prevent the formation of large clinkers.

The combustion section 3 has a vibrating fire grate 60 and a pusher 61; the upper circumferential wall 62 thereof is composed of refractory. An opening 63 for discharge of residue is provided in the lower portion of the combustion section 3 and is connected to an ash tray 65 which is provided with a pusher 64 to facilitate the removal of ash. The combustion section 3 also has an opening 66 for the input of combustion air, an auxiliary burner 67, and an opening 68 for the discharge of waste gas.

Ancillary equipment to the combustion apparatus comprises a skip hoist 69 for charging refuse, a means 70 for rotating part of gasifying section 2 and driving means 71, 72 and 73.

For purposes of economy it is desirable to make the circumferential wall of said gasifying section 2 partly water cooled so as to utilize the lost heat from the wall surface for producing steam and to mix the steam with a gasifying agent blown into the dry distillation section 52 and the gasifying section 2 respectively through openings 57 and 58.

In accordance with the embodiment shown in FIG. 6, part of the combustible gas rising from gasifying section 2 is burned by means of gasifying agent injected through blowing nozzle 57 into the lower portion of dry distillation section 52, and an exothermic reaction proceeds. The gasifying agent referred to consists of humidified air together with recycled waste gas. As the distillation and oxidation of the refuse take place in the dry distillation section 52, the temperature of the waste gas rising from the dry distillation section is maintained high, in general, higher than 300°C, so that effective drying conditions are maintained even for refuse having widely varying moisture contents. Dry distillation and drying proceed rapidly even when gas injected through nozzle 56 is decreased or cut-off entirely if circumstances so require.

The refuse subjected to dry distillation and partial oxidation in the dry distillation section 52 subsequently reaches the gasifying section 2 where gasifying is carried out by the mixed gas blown in through nozzle 52 and by the high temperature gas rising through the fire grate 59 from the combustion section 3. This procedure gasifies both the volatile components and part of the fixed carbon of the refuse. Also, the harmful components such as sulphides, chlorides and other halogens, etc. are gasified by thermal decomposition of the refuse.

The refuse loses a large portion of its weight and volume in the gasifying section 2 and then enters combustion section 3 where it reacts with blast air entering through opening 66 and is subjected to the heat of the auxiliary burner 67. The ash contains a negligible quantity of unburned organic material and consists mostly of clinker. The clinker is dropped by means of pusher 64 into ash pan 65 and is discharged by a conveyor (not shown) after cooling. Most of the exhaust gas from combustion is lead to the outside through opening 68 and utilized in heating the air to serve as the gasifying agent in section 2 and in the dry distillation section 52. It is subsequently released through a stack into the atmosphere after passing through waste heat recovery apparatus and a dust collector. The remainder of the exhaust gas from the combustion section rises through the gasifying section 2 and accelerates the gasification reaction. The waste gas leaving drying section 1 is treated as above to remove noxious and corrosive components.

As is evident from the above description, incineration apparatus in accordance with the present invention provides for treating refuse consisting of many types of waste materials through consecutive steps of drying, dry distillation, partial oxidation and complete combustion without discharge of noxious or corrosive components to the environment. Furthermore, in the present process waste heat is effectively utilized and an exhaust gas of substantial calorific value is produced as a by-product. The capacity of the system can be scaled up to as great an extent as may be desired, the cost of the system is relatively low and the expense of operation is also low.

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 method and in the construction 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 method of disposing of refuse without emission of noxious gases comprising the successive steps of drying, gasifying and combustion of said refuse while moving said refuse downwardly through three regions in each of which one of said steps is carried out, wherein a portion of the exhaust gases formed during said combustion step are passed upwardly into said gasifying region, thence to said drying region and out of said drying region, said exhaust gases containing gases and vapors produced in said gasifying region and being first treated to remove noxious and corrosive components after which a portion of said treated exhaust gases is recycled in part to said drying region and in part to said combustion section to serve as auxiliary fuel, the remainder of said treated gas being optionally stored for use as fuel or vented.
2. The method of claim 1, wherein a portion of the exhaust gases formed in said combustion of said refuse in said third region passes upward into said second region to cooperate with said humid gas in gasifying said organic components, with the remainder of said exhaust gases being led to the exterior of said third region to heat said air which, in part, enters said third region as blast air and which, in part is humidified and then enters said second region.

3. The method of claim 1, wherein the quantity, temperature and humidity of said humid air introduced into said second region are controlled to provide suitable conditions for gasification while preventing combustion of said refuse in said second region.

4. An apparatus for disposing of refuse without emission of noxious by-products, comprising a drying section having a port for the introduction of refuse and a dried refuse port proximate the lowest portion thereof for passage of dried refuse therefrom in a downward direction and for passage of hot gas in an upward direction, a waste gas exit port leading from said drying section, a hot gas inlet port leading into said drying section for introduction of heated gas free of noxious components, a gasifying section communicating proximate the uppermost portion thereof with said drying section by means of said dried refuse port, an input port proximate the lower portion of said gasifying section for the introduction of heated, high-humidity air, a gasified refuse port proximate the lowest portion of said gasifying section for passage of gasified refuse therethrough in a downward direction and for passage of combustion exhaust gases therethrough in an upward direction, a combustion section communicating proximate the uppermost portion thereof with said gasifying section by means of said gasified refuse port, an incinerator in said combustion section, a first input port for introduction of heated, blast air, a second input port for introduction of recycled waste gas freed of noxious by-products from said waste gas exit port and a residue exhausting port proximate the lowest portion of said combustion section for the removal of non-gaseous products formed in said combustion section.

5. An apparatus for disposing of refuse without emission of noxious by-products as defined in claim 4, wherein said combustion section comprises a downwardly reflecting wall in the upper portion thereof for reflecting heat to the contents thereof.

6. An apparatus for disposing of refuse without emission of noxious by-products as defined in claim 4, wherein said combustion section has a burning zone therein and is provided with a refractory wall in the upper portion thereof.

7. An apparatus for disposing of refuse without emission of noxious by-products as defined in claim 4, further comprising a dry distillation section intermediary said drying section and said gasifying section, said dry distillation section communicating proximate the uppermost portion thereof with said drying section by means of said dried refuse port, and having proximate the lowest portion thereof a dry-distilled refuse port communicating with said gasifying section for transfer of dry-distilled refuse in a downward direction to said gasifying section and for passage of hot humid gas from said gasifying section in an upward direction.

8. An apparatus for disposing of refuse without emission of noxious by-products as defined in claim 4, further comprising a dephlegmator for removal of offensive by-products from said waste gas prior to recycle of portions of said waste gas to said drying section and said combustion section.

9. An apparatus for disposing of refuse without emission of noxious by-products as defined in claim 4, wherein said gasifying section is frustoconical in shape and is rotatable for the purpose of controlling the rate of passage of refuse therethrough.

10. An apparatus for disposing of refuse without emission of noxious by-products as defined in claim 9, wherein said gasifying section is water-cooled.