METHOD AND APPARATUS FOR CLEANING SOLIDS FOR POLLUTION FREE DISPOSAL

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ABSTRACT
A system for burning a hydrocarbon coating, such as an oil coating from the surface of particulate solid material such as sand in a pressurized firing zone or firing chamber where the solids are introduced under pressure into the firing zone. An air-fuel mixture is introduced into the firing zone and burned therein. The burning of this air-fuel mixture at high temperature and under pressure will burn the hydrocarbon coating from the solid material. Immediately downstream of the firing chamber is a doughnut restriction which confines the combustion to the firing chamber. The ratio of air to fuel in the air-fuel mixture is always such that the fuel will be completely burned. The system will be provided with controls to shut the unit down when the temperature goes above or below a predetermined temperature and also to shut the system down when a lack of complete combustion of the fuel is indicated. The combination of the complete combustion of the fuel and the use of the restriction which confines the flame to the firing chamber permits the use of the system in an otherwise hazardous area.

5 Claims, 4 Drawing Figures
METHOD AND APPARATUS FOR CLEANING SOLIDS FOR POLLUTION FREE DISPOSAL

This is a division of application Ser. No. 110,826, filed Jan. 29, 1971 now U.S. Pat. No. 3,734,774.

The present invention relates to the burning of a hydrocarbon or oil coating on the surface of solid materials such as sand so that the sand can be discarded without polluting the land or water where it is dumped. More particularly, the present invention relates to the burning of this hydrocarbon coating from the sand in a safe manner in an otherwise hazardous area.

Solids, such as sand, are often entrained in the oil flow from an oil well. In such a case, it is conventional to pass the oil flow to a desander which consists of cone wherein the oil flow is conducted through the cone in a whirling motion allowing the clean oil to exit through the top of the cone and the sand to fall by weight to the bottom of the cone. The sand is held in a receiver at the bottom of the cone and is dumped under pressure as the sand accumulates. However, this sand still has a coating of oil or hydrocarbon on the surface and, as such, constitutes a pollutant. At the present time there is no acceptable method of treating the sand to remove the hydrocarbon coating in a safe and economical manner.

The present invention involves a novel method and apparatus for burning the hydrocarbon coating from the surface of the sand. The polluted sand is introduced under pressure into a pressurized firing chamber. Prior to the introduction of the sand into the firing chamber, a fuel-air mixture is introduced into the firing chamber and ignited therein. The air-fuel mixture is maintained at such a ratio that the fuel is always completely burned so as to eliminate any possible hazard at the downstream end of the unit. Controls are provided to maintain a certain predetermined temperature within the firing chamber. Controls are also provided to sense the complete combustion of the fuel and, that failing, to shut the unit down. Immediately downstream of the firing chamber, is a doughnut or restriction which points the flame and confines it to the firing zone. The spent, burned gases and solids are introduced into a vortex tank at the end of the unit from which the gases are sent to the atmosphere through a flash arrester and the solids are discharged downwardly into the ocean or on the land.

In light of the above, it is a principal object of the present invention to provide a safe and inexpensive method and apparatus for removing a coating of hydrocarbon or oil from the surface of a solid particulate material such as sand.

It is a further object of the present invention to provide a method and apparatus of the type referred to herein which will permit the disposal of the so treated solids in a pollution free manner.

It is a further object of the present invention to provide a method and apparatus of the type referred to herein wherein the combustion of an air-fuel mixture takes place in a pressurized firing chamber and wherein the air-fuel mixture is always maintained to provide complete combustion and wherein the solid particulate material is introduced into the combustion zone to remove the coating of hydrocarbon or oil therefrom.

It is a further object of the present invention to provide a method and apparatus of the type referred to above which includes automatic controls for maintaining the temperature within the firing zone within predetermined limits.

It is still a further object of the present invention to provide a method and apparatus of the type referred to above which includes controls for shutting the unit down when complete combustion fails to occur.

Other and further objects and advantageous features of the present invention will hereinafter more fully appear in connection with a detailed description of the drawings in which:

FIG. 1 is an elevation, partly semi-diagrammatic, of a disposal unit constructed in accordance with one embodiment of the present invention;

FIG. 2 is a longitudinal sectional view, partly diagrammatic, showing details of the firing chamber of the present invention;

FIG. 3 is a transverse sectional view taken along section line 3-3 of FIG. 2; and

FIG. 4 is a transverse sectional view taken along section line 4-4 of FIG. 2.

Referring to the drawings in detail, FIG. 1 shows a firing chamber or furnace 16, a restriction member 12 (later to be described), a horizontal extension (or secondary) tube 14, an angled extension tube 16, and a receiving tank 18; the foregoing elements are connected together by suitable flanges and bolts, etc. (the details of which are considered conventional) and are supported by vertical members 20, 22 and 24 and inclined bracket 26.

As indicated heretofore, this apparatus is designed to burn oil or hydrocarbons from solids, such as sand from oil wells. It is conventional practice to separate the sand from the oil flow by a whirling motion in a cone (de-sander), allowing the clean oil to exit through the top of the cone and the sand to fall by gravity to the bottom of the cone. The sand is held in a receiver or holding pot beneath the cone and is dumped under pressure out of the de-sander. Thus, the sand, which has a coating of oil or hydrocarbon, is taken from the de-sander (not shown, but as described above) and introduced into firing chamber 10 through suitable valves (not shown) and through the conduit 28 which leads directly into the firing nozzle 30 (see now FIGS. 2, 3 and 4).

The elements 10, 12, 14 and 16 are lined with ceramic or refractory material liners 32, 34 and 38 (not shown), respectively. Purely for illustrative purposes and not by way of limitation, the outer diameter of the elements 10, 12, 14 and 16 can vary from 9 to 10 to 12 to 18 inches for a BTU input ranging from 0.5 to 1 to 2 to 4 million, respectively. The thickness of the ceramic or refractory layer 32 in the firing chamber is preferably about 3 for the smaller diameters to 4 inches for the largest diameter and since the thickness of the metal wall 40 is about one-fourth inch, the resulting open area or central bore 42 will have a diameter of 3, 4, 6 and 10 inches, respectively, as related to the indicated outer diameters.

The refractory layer in the "do-nut" restriction should be of such thickness as to leave a resulting bore of about 1 1/4, 3, 4 1/2 and 7 inches in diameter for the outer diameters, respectively, indicated above.

As far as the extension pipes 14 and 16 are concerned, each of the ceramic layers 36 and 38 (not shown) will have a thickness of about 2 inches so as to leave an open central bore diameter of about 5, 6, 8...
and 14 inches, respectively, for the indicated outer diameters.

Surrounding the tip 46 of the nozzle 30 is a metal cup 48 whose outer diameter will vary from 1 1/2 inches to 5 inches while the corresponding outer diameter of the nozzle 38 will vary from 1 inch to 3 inches over the range of diameters indicated for the firing chamber 10. The tip 46 of the nozzle is flared inwardly to provide an open nozzle area of five-eighths to 2 inches. The annular space 50 between the cup 48 and the nozzle 30 is filled with ceramic or refractory material as shown.

As indicated heretofore the polluted sand is forced through the nozzle 30 by any convenient pressure source (not shown). The sand passes into the chamber 42 through the tip 46 of the nozzle. A suitable fuel, such as natural gas, in introduced under pressure from a pressure source 51 and through suitable valving 52 into the conduit 53 which connects with the inner nozzle 54, the latter being a smaller pipe mounted concentrically within the outer nozzle 30. The fuel passes out of the tip 56 of the inner nozzle into the chambers 42. The diameter of the tip 56 will vary from three-eighths to 1 inch as related to the varying dimensions, respectively, indicated above.

A supply of air for combustion is provided by a blower 60 whose outlet 62 connects with a conduit 64 through a plurality of valves one of which is shown as valve 66. The conduit 64 leads tangentially into a circular manifold 66 which surrounds the nozzle 30 at the inlet to the firing chamber 10. Air will pass into the chamber 42 through the annular space between the cup member 48 and the liner 32. The air manifold has a first end opening 70 which is covered by a sight glass 72 and a second (pilot) opening 74 which CONNECTS WITH A PILOT CONDUIT 76. The conduit 76 connects with the fuel source 51 in a manner not shown completely but at least through one valve such as valve 78.

After the oil or hydrocarbon has been burned from the sand, as will be described hereinafter in greater detail, the hot spent sand passes through the doughnut member 12, the tube 14, the angled tube 16 and into the receiving tank 18. The angled extension tube 16 connects with the receiving tank 18 through an inlet opening or conduit 80 which leads tangentially into the receiving tank 18 so as to provide a swirling action therein. This swirling action sets up a vortex which throws the solids out and down to the bottom of the receiving tank 18 while the hot gases exit through a flash arrester 82 on the top of the tank; these hot gases will be free of combustibles due to the controlled fuel and air mix which is burned, as will hereinafter appear. As the solids built up to a predetermined level in the bottom of the tank 18, they will activate a solids probe 84 which will control a dump valve 86 to permit discharge of the solids from the tank 18 through the outlet conduit 88.

The firing chamber 10 is provided with four devices for controlling and/or indicating the operation within the chamber 42; these four items are shown semi-diagrammatically in FIGS. 2 and 4. Item 90 is a temperature probe whose purpose and operation will be described hereinafter; Item 92 is simply a thermometer which provides a local visual indication of the temperature inside the chamber 42. Item 94 is an electric pilot ignitor which ignites the pilot gas; and Item 96 is a flame-sensing fail-safe control device (for example, the flame sensor 96 can be a Honeywell Type RA-890-6 flame unit.)

The units 90, 92 and 94 are all directed radially inwardly towards the center of the chamber 42. The flame-sensing unit 96, however, is offset about forty-five degrees from the unit 90 and is directed downwardly at an angle towards the burner tip 56. The control elements 90, 94 and 96 connect by means of suitable wiring (not shown) with a control panel 98 (the details of which are not shown); by the use of conventional solenoids, relays, valves, timing devices, etc. (not shown), the operation within the firing chamber 10 can be controlled automatically. For example, the temperature probe 90 (through suitable circuitry within the control box 98) can control the operation of a proportional valve 100 which, through suitable linkage diagrammatically indicated at 102, can control a fuel valve 52 and an air valve 66 simultaneously so as to provide a constant air-to-fuel mixture.

OPERATION

As indicated above, the control panel or box 98 contains a plurality of controls which are essentially of a conventional nature. When the operation of the disposal unit of the present invention is initiated, certain valves, solenoids, etc. are closed and opened in a predetermined cycle of operation. This cycle of operation will now be described in terms of results rather than describing in detail the opening and closing of various relays, etc. At any event, when the unit is first turned on, the fuel line, the pilot line, the solids line all remain closed. The blower 60 is actuated to blow air through the unit to purge the system. After the purging cycle has been completed, the valve 66 is substantially closed except for a small opening therein sufficient to provide air for the air for the pilot. Thereafter, the pilot valve 78 is opened and pilot fuel will pass into the chamber 42. Shortly thereafter, the electric pilot igniter 94 will receive a 6,000 volt charge (for example) to ignite the pilot mixture. The flame sensing unit 96 is adapted to lock on ultraviolet and actuate a relay which will permit fuel and solids to be introduced into the unit. The unit will be designed to operate between 500° Fahrenheit and about 3,000° Fahrenheit, depending upon the condition of the polluted sand. At any event, depending upon the control setting used, the temperature probe 90 will now operate the valves 52 and 56 in unison to provide a constant air-to-fuel ratio in the mixture. As the solids are now introduced through the conduit 28 through the nozzle 30, the high temperature combustion will burn the oil or hydrocarbon off the surfaces of the sand particles.

If, per chance, someone were to use a fuel of a different BTU rating for which the controls were set, the flame sensing unit would no longer sense ultraviolet, the relay controlled by the flame-sensing unit 96 would be closed and the entire unit would be shut down immediately. Likewise, if the temperature were to vary substantially above or below the control setting, the temperature probe 90, through its control circuit within the control panel 98 would also cause the system to be shut down completely.

Although it has been indicated earlier that the fuel employed could be natural gas, it is possible to use other gaseous or liquid fuel; however, it must be kept in mind that the initial setting of the air and gas valves will be dependent upon the BTU rating of whatever fuel is em-
ployed, thus, when changing from one fuel to another, it will be necessary to adjust the operation of the air and the fuel valves to guarantee complete combustion.

The process employed in the apparatus of the present invention is one which exposes solids to direct fire in a pressure vessel which is designed to operate in a hazardous area such as in connection with oil and gas producing operations. As the burning takes place in the chamber 42, the fire and the solids are forced through the doughnut restriction 12 causing the flame to point and thereby prevent it from extending downwardly into the extension pipe 14. Thus, the opening 44 as compared with the diameter of the chamber 42, constitutes a restriction which sets up a back pressure for holding the fire in the combustion area 42. The greater the flame velocity, the greater the restriction.

Summarizing, the present invention permits the burning of contaminated solids by exposing them to flame to purify the solids for disposal; thus, on land, the sand can be dumped substantially anywhere; at sea, the sand can be dumped back into the ocean without fear of polluting the water. Secondly, the present invention provides for the burning of hydrocarbons from the surface of these solids in a safe manner in an otherwise hazardous area by the use of firing in a pressurized area with the back pressure being held on the combustion area by the use of an internal restriction; also, it is important that the firing be controlled by a pre-set fuel-air mixture with automatic controls for shutting down the unit immediately when the operation of the unit deviates from the intended mode of the operation.

Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications, apart from those shown or suggested herein, may be made within the spirit and scope of this invention.

Of course, it should be understood that the air-fuel ratio is always somewhat in excess of the air required to burn the fuel alone because some of the air will be utilized to burn the hydrocarbon coating from the sand. With this idea in mind, the amount of air will always be in excess of that required to burn the fuel and the hydrocarbon.

I Claim:

1. Apparatus for burning a hydrocarbon coating from the surface of particulate solid material which comprises a furnace having a firing chamber therein, means for introducing an air-fuel mixture under pressure into the chamber adjacent one end of said chamber, means for maintaining the air-fuel ratio in the air-fuel mixture at a substantially constant value, means for igniting the air-fuel mixture in the firing chamber, means for introducing said solid material containing the hydrocarbon coating under pressure into said firing chamber adjacent said one end of said chamber for burning the hydrocarbon coating therefrom, the burned solid material and the combustion gases being forced by said pressure towards the open opposite end of said chamber, a restriction mounted at said opposite end of said chamber and having an opening therein smaller than the cross sectional area of said firing chamber for confining the combustion flame substantially to said chamber, and means downstream of said restriction for receiving the combustion gases and the spent solid material for discharging the gases to the atmosphere and for dumping the solids to waste.

2. The improvement according to claim 1 including a first nozzle located centrally with respect to said one end of said firing chamber for introducing the fuel under pressure into said chamber, a second nozzle concentrically surrounding said first nozzle for introducing the solid particulate material into said chamber and an air manifold surrounding the said second nozzle for introducing the air into said chamber through the resulting annular space between said second nozzle and the sides of said chamber.

3. The improvement according to claim 2 including a first valve means for controlling the supply of air to said chamber, a second valve means for controlling the supply of fuel to said chamber, a temperature sensing means mounted within said chamber and means responsive to said temperature sensing means for controlling said first and second valves in unison while maintaining a fixed air-fuel ratio in the resulting air-fuel mixture in said chamber.

4. The improvement according to claim 3 including means for introducing pilot fuel into said chamber and electrical ignition means in said chamber for igniting said pilot fuel.

5. The improvement according to claim 4 including a flame sensing means in said chamber for sensing the complete combustion of the air-fuel mixture in said chamber and for stopping the flow of fuel, air and solids to said chamber in the absence of said complete combustion.