EXPLOSIVE-PROOF METHOD AND INCINERATOR FOR BURNING DRILL CUTTINGS

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Abstract

An incinerator for removing hydrocarbon residues and other organic and inorganic components from oil and gas well drill cuttings is submerged in water to make the assembly explosive-proof with respect to the drilling rig. One embodiment uses a basket with a removable bottom in the combustion chamber to retain the cuttings during the burning. An alternate embodiment uses a series of metal plates for such retention. After burning, the pollution-free cuttings are discharged from the combustion chamber beneath the surface of the water to eliminate sparks which might otherwise also cause an explosion. A belt-driven scoop located beneath the combustion chamber provides a means of testing the burned cuttings for unburned pollutants.

16 Claims, 4 Drawing Figures
EXPLOSIVE-PROOF METHOD AND INCINERATOR FOR BURNING DRILL CUTTINGS

BACKGROUND OF THE INVENTION

On both offshore and inland drilling barge and rigs, drill cuttings are conveyed up the hole by drilling fluid. Since it is quite common to use hydrocarbons in one form or another in such drilling fluids, some water and gas wells, the formation particles or cuttings become exposed to the hydrocarbons or other organic and inorganic components of the fluid, thus adding to any oil originally contained within the cuttings. The cuttings frequently retain some of these components despite the use of various vibrating screens, mechanical separation devices and various chemical and washing techniques. Because of pollution to the environment, whether water or land, the cuttings cannot be permanently discarded until the pollutants have been removed. It should be appreciated that although the burning of the cuttings provides an excellent means for eliminating the pollutants, such has never been seriously considered by those in the art because of the danger of explosion and fire on the drilling rig.

It is therefore the primary object of the invention to provide a novel apparatus for disposing of the pollutants in oil and gas well drill cuttings;

It is another object of the invention to provide an improved incinerator for burning oil and gas well drill cuttings which is explosive-proof with respect to a drilling rig;

It is yet another object of the invention to provide an improved apparatus for dumping the drill cuttings beneath the surface of the adjacent water environment; and

It is still another object of the invention to provide a novel method for removing pollutants from oil and gas well drill cuttings.

The objects of the invention are accomplished, broadly, by the provision of an incinerator which is submerged in a body of water to prevent explosion to the drilling rig or dumping barge. After burning, the cuttings are discharged from the combustion chamber beneath the surface of the water to eliminate sparks in the vicinity of the drilling rig.

These and objects, features and advantages of the invention will become apparent from a reading of the following detailed specification and accompanying drawings, in which:

FIG. 1 is a side elevational view of an incinerator according to the invention mounted on a drilling rig having a water environment;

FIG. 2 is an enlarged schematic view, partly in cross section, of the incinerator according to the invention;

FIG. 3 is an enlarged schematic view, partly in cross section, of an alternative combustion chamber for the incinerator according to the invention; and

FIG. 4 is a top plan view, partially in cross section, of one of the inner compartments of the combustion chamber illustrated in FIG. 3.

In FIG. 1, there is illustrated an offshore drilling barge 10 having a work platform 11 supported off the ocean floor 12 by a plurality of columns 13. The invention contemplates the disposing of pollutants encountered in drilling with floating offshore barges, as well as with drilling barges used in marshy areas or inland lakes. The present invention will also be used in other remote areas, such as the frozen northernmost areas of the world, wherein there is danger of pollution to the ice and snow, and to the water areas associated with such ice and snow.

A conventional drilling derrick 14, with its associated draw works, is mounted on the work platform 11 for drilling a well 15 into the earth formations 16 lying beneath the ocean floor 12.

A drill pipe 17, having a drill bit 18 at the lower end, is connected to the rotary table and draw works associated with the derrick 14, all of which is conventional and illustrated herein solely for purposes of showing how the drill cuttings are polluted.

A mud pit 20 is connected by way of the mud line 21 and mud pump 22 to a mud hose 23 and swivel 24, such that drilling mud is pumped into the top of the drill pipe 17, down through the length of the drill pipe and is pumped into the bottom of the borehole 15 through the drill bit 18. A portion of the borehole 15 is cased with a cement sheath 19.

Near the top of the cased borehole, a mud pipe 25 returns the mud through a shale shaker screen 26 located above the mud pit 20.

During the drilling operation, the mud is pumped down through the drill pipe, shown by the downwardly pointed arrow, and into the bottom of the borehole. Further pumping of the mud causes it to be pumped up, shown by the upwardly pointing arrow, between the casing 19 and the drill pipe 17, and into the mud return pipe 25. As the drill bit 18 cuts into the earth, the "drill cuttings" or portions of the rock and earth are carried back to the earth's surface via the mud. Upon leaving the mud return line 25, the combined mud and drill cuttings are pumped into the shaker screen 26, the screen being sized to pass the mud back into the mud pit 20 while retaining the drill cuttings of any appreciable size. The process can be repeated over and over again by continuing to pump mud from the mud pit 20 back through the drill pipe as previously explained. The cuttings retained by the shale shaker screen 26 are then conveyed by a conveyor belt 30 into an accumulation chamber 31, or can be manually transferred, as by a shovel, to the chamber 31, if desired.

As previously noted, such cuttings frequently have huge, cumulative amounts of various organic and inorganic pollutants associated therewith, quite often of the hydrocarbon variety. As such cuttings are not suitable for direct disposal into the surrounding environment, especially into the surrounding water, the pollutants must be removed prior to dumping the cuttings into the water. It should be appreciated that the only practical alternative, i.e., the transporting of the cuttings back to the shore, is both time consuming and otherwise uneconomical.

The chamber 31 is an upper portion of a subsurface furnace 33 which is designed to either be maintained beneath the surface of the water, or alternatively, be filled with the cuttings and then lowered beneath the surface. However, the furnace 33 is preferably maintained beneath the surface of the water to lessen the change of fire to the drilling rig.

A cuttings trap 35 is located immediately beneath the bottom of the furnace or incinerator 33, being mounted on an endless belt or cable 36 for transport of the trapped cuttings to the work platform 11. Thus, when desired, samples of the burned cuttings can be tested by personnel working on the platform 11. However, the testing processes could be automated, if desired, to determine that the cuttings are properly burned. Although not illustrated, those skilled in the art will recognize that this could be accomplished by causing the belt 36 (and the sampled drill cuttings) to be passed through various automated machines and apparatus located on the platform 11 capable of such analysis.

Referring now to FIG. 2, there is illustrated in greater detail the accumulator 31, the incinerator 33, and various structures intermediate the accumulator and incinerator, as well as the sensors and controls associated therewith.

After a sufficient number of the cuttings 39 have been accumulated in the accumulation chamber 31, a valve 40 is caused to be opened, thus allowing the cuttings to drop or move into a pressure chamber 41. Pressure chamber 41 is isolated from the combustion chamber 42 of the incinerator 33 by a valve 43. After the pressure chamber 41 is properly loaded with the cuttings, valve 40 is closed and pressurized air is pumped into pressure chamber 41 through the air line 44 connected to the air compressor 45. When the pressure in pressure chamber 41 is equal to or slightly greater than the pressure in the combustion chamber 42, valve 43 is caused to open, allowing the cuttings to drop or move into the combustion chamber 42. Since the pressure has been substantially equalized between chambers 41 and 42, and because pressurized air is being
pumped into pressure chamber 41, there is no tendency of heat to rise from the combustion chamber 42 into the pressure chamber 41, substantially all of the heat flow being in the downward direction. After the cuttings are discharged from pressure chamber 41 into the combustion chamber 42, valve 43 is closed and the three-way valve 46 in air line 44 is opened discharging pressure through outlet 47, thus restoring pressure chamber 41 to atmospheric pressure. Valve 40 can then be opened and the pressure chamber 41 again loaded with cuttings, allowing the process to be repeated. It should be appreciated that the valves 40 and 43 can be of the rotary vane type for more continuous operation by a proper maintenance of the pressure within the pressure chamber 41.

A basket 50 is attached to the sides of the combustion chamber by the arms 51, the basket 50 being positioned beneath the valve 43 to receive the cuttings from the pressure chamber 41. The mesh size of the basket 50 is selected to be finer than the mesh of the screen of the shale shaker 26 illustrated in FIG. 1, whereby the cuttings will not pass through the basket prematurely. The bottom 52 of the basket is connected to the piston 53 of air cylinder 54 inside the basket control box 57 which in turn is activated by the air pressure line 55 from the air pump 66 connected by the conductor 67 to the control station 65. In operation, the piston 53 is extended to close the bottom of the basket and retracted to release the cuttings from the basket. If it is desired that a basket be unloaded, those in the art will recognize that the bottom may be removed in various other ways, for example, by a pivotal hinging of a single bottom, or by using two or more bottom doors, as with shutters.

However, an alternative embodiment requires no basket. It is contemplated that the apparatus merely makes use of the gravity assisted flow of gases from the top of the combustion chamber 42 to the bottom outlet 56. A fuel pump 60 is mounted on the work platform and is connected through the fuel lines 61 to the plurality of nozzles 62. Although the fuel used in the combustion chamber could be solid, liquid or gaseous, the preferred embodiment contemplates the use of diesel fuel. A conventional electric starter 63 for each of the nozzles 62 is connected by way of the conductor 64 to the control station 65 located on the work platform 11.

A heat sensor 70 mounted on the pressure chamber 41 is connected through the conductor 71 to an alarm system 72, for example, a siren or a buzzer. Should the pressure chamber become overheated due to a malfunction of the combustion chamber, the alarm system alerts the drilling personnel to such danger. Additionally, the heat sensor 70 is connected through conductor 73 to the safety valve 74. Upon a sensing of overheating, the valve 74 opens, causing the combustion chamber 42 to flood with water, extinguishing the flame at the nozzles 62 and cooling the interior of the combustion chamber and all of its contents. The sensed overheat condition is also coupled immediately back from the control station by the conductors 75 and 76 to the fuel pump 60 and the air pump 45, respectively, thus stopping all fuel and air mixtures from further entry into the combustion chamber.

A heat sensor 77 is mounted on the combustion chamber 42 and is connected by conductor 78 to the fuel pump 60 and air pump 45 to control the air/fuel ratio in order to sustain the combustion chamber at a proper and efficient temperature. A coupling 80 joins two sections of the pressure chamber 41. In the event of malfunction, the entire submerged assembly can easily be retrieved by disconnecting the coupler 80. To restore operation, the two sections of the pressure chamber are again coupled by the coupler 80. Sufficient air pressure is then reestablished in chambers 41 and 42 to remove all water from the combustion chamber 42 and pressure chamber 41. Valve 43 is then closed, electric starter 63 is activated, and fuel oil is pumped into the combustion chamber, thus causing ignition. When heat sensor 77 indicates combustion, the process of burning cuttings can again be commenced.

Mechanical vibrators or shakers 85 and 86 are mounted on the sides of the pressure chamber 41 and the combustion chamber 42, respectively, each being connected by the conductor 87 to the control station 65. In the event certain types or sizes of drill cuttings show a tendency to stick to the sides of the chambers, the vibrators will cause such cuttings to be released.

Subsequent to the cuttings being thoroughly burned, and all the pollutants being thus removed, the cuttings are released from the basket 50, whereupon they fall into the open lower end 56 of the combustion chamber 42. The water, part of which forms a hydrostatic head in the outlet 56, quenches the heat of the cuttings. Since the specific gravity of the cuttings is greater than that of water, the pollution free cuttings will settle to the bottom, for example, to the ocean floor.

In FIG. 3, there is illustrated an alternative embodiment of the submerged combustion chamber 90 for the incinerator 91. A pressure chamber 92 is connected through a valve 93 to the uppermost portion of the combustion chamber 90 in a manner analogous to the manner shown for the chambers 41 and 42 and valve 43 in the embodiment of FIG. 2, except the pressure chamber 92 is off-center, as is described hereinafter. Although not illustrated, the upper section of the pressure chamber 92 is normally connected to an accumulator such as the accumulator 31 of FIG. 2.

Located within the combustion chamber 90 is a plurality of vertically spaced plates 94, 95, 96, 97, and 98, each of which has a corresponding discharge part 94a, 95a, 96a, 97a, and 98a, respectively. The discharge parts are staggered such that no two adjacent metal plates have discharge parts lying in the same vertical plane. A rotatable shaft 99 runs down the centerline axis of the incinerator 91, having a gear drive 100 connected to a motor 101 controlled by a motor control 102. The motor is preferably of the variable speed variety to allow flexibility in the retention time for the cuttings at each level within the combustion chamber. For example, the motor can be a rotary torque actuator, such as a reciprocating piston driven rack and pinion device through a cam type overriding clutch. In such example, the actuator can be operated by compressed air, wherein a change in air volume causes a change in the rotational speed of the shaft 99. It should be appreciated, however, that other types of variable speed motors 101 can be used to rotate the shaft 99, and that even a constant speed motor can be used if no flexibility of cutting retention is desired.

A leveling and spreading blade 103 and a scraping blade 104 are connected to the shaft 99, the scraping blade being set to pass a given distance above the plate 94, for example, 2 or 3 inches, whereas the scraper blade 104 barely clears the plate 94 as the shaft 99 rotates. Similar sets of spreading blades and scraping blades are verti-
Referring again to FIG. 3, there is mounted a magnet 112 on the shaft 99 for monitoring the rotational position of the shaft 99 and the blades attached thereto. A position sensor 113, for example, a reed relay is mounted on the work platform 11 responsive to the magnet 112 rotating past the sensor. An electrical conductor 114 connects the sensor 113 to an air compressor 115, which in turn is connected through the air line 116 to the valve 93. Likewise, a pair of magnets can be used on the shaft 99, one to open the valve 93, and one to close the valve 93. Those skilled in the art will recognize that other devices can be used to regulate the opening of the valve 93 with respect to the position of the blades 103 and 104, such as, for example, a cam attached to the shaft 99 with mechanical or hydraulic linkage to the valve 93. Preferably, the valve 93 is opened and the cuttings dumped onto the plate 94 immediately before the leveling and scraping blade 103 comes into contact with such cuttings as the shaft 99 rotates.

In the operation of the apparatus of FIGS. 3 and 4, it should be appreciated that the cuttings are released from the pressure chamber 92, through the valve 93, onto the metal plate 94. As the blade 103 is caused to move clockwise (in FIG. 4), the cuttings are spread and leveled over the surface of the plate 94. The rotational speed of the shaft 99 is set such that the cuttings remain at each level for approximately 1 minute, or a total retention at the five levels of 5 minutes. However, the speed of rotation can be varied, as discussed above, to provide different retention times even different for the different levels if desired. During the first minute (at the first level), the moisture content of the cuttings is reduced considerably.

As the scraper blade 104 comes around, the cuttings are caused to be scraped or dropped through the discharge part 94c onto the metal plate 95 at the next lower vertical level. As the cuttings are being spread and leveled by the blade 109, the nozzle 105 and its associated flame provides the heat for initial start-up, causing ignition of the hydrocarbon content of the cuttings. It has been found that a gallon per hour fuel capacity is adequate for such purposes. After the 1 minute retention, the scraper blade 108 causes the cuttings to be dropped through the discharge part 95c to the next level, metal plate 96. Similar leveling and scraping at the succeeding lower vertical levels causes the burning cuttings to be moved to the plates 97 and 98, thus remaining in the combustion chamber for 5 minutes. This has been found to be adequate time for complete burning of the hydrocarbons in several types of oil base cuttings tested in the apparatus. Finally, the pollution-free cuttings are discharged through the part 96c and through the open end 110 of the combustion chamber 90. If desired, a spring-load valve (not shown) may be used at the end 110 to prevent water entry if air pressure is lost.

It should be appreciated that the entire combustion chamber 90 is maintained beneath the surface 32 of the water, just as with the embodiment of FIG. 2, to substantially eliminate the danger of explosion. Furthermore, the presence of the infinite supply of water to continually cool the walls of the incinerator eliminates or substantially lessens the need for refractory materials or other linings except as may be used to forestall corrosion or flame abrasion.

The embodiments of the invention have been described and illustrated, it should be appreciated that other means can be used to move the cuttings from the top to the bottom of the combustion chamber, such as screw conveyors, rotating drums, and the mere use of gravity assisted by the passage of hot gases. Those skilled in the art will also recognize and appreciate the fact that the incinerator can be placed on the derrick floor and water, or some other suitable location, be lifted by pump to cool the exterior of the combustion chamber and cause such chamber to be effectively submerged in an explosive-proof medium. Further, it should be appreciated that positive action scrubbers can be used on the exhaust gases if desired, to further aid in combustion pollution.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An explosive-proof apparatus for burning hydrocarbons from drill cuttings on an offshore drilling barge, comprising:
   - means for accumulating drill cuttings above the surface of the water; and
   - submerged means for burning said cuttings beneath the surface of the water.

2. An explosive-proof apparatus for burning hydrocarbons from drill cuttings on an offshore drilling barge, comprising:
   - a cuttings incinerator arranged to be submerged beneath the surface of the water;
   - means for placing said cuttings into said incinerator; and
   - means for displacing said cuttings from said incinerator into the water after burning.

3. The apparatus according to claim 2, including in addition thereto means for obtaining a sample of the cuttings after displacement from said incinerator.

4. An explosive-proof apparatus for burning hydrocarbons from drill cuttings on an offshore barge, comprising:
   - an accumulator for accumulating said cuttings;
   - a combustion chamber submerged beneath the surface of the water;
   - an air-presurized chamber connecting said accumulator with said combustion chamber;
   - a first valve between said accumulator and said air-presurized chamber; and
   - a second valve between said combustion chamber and said air-presurized chamber, whereby the sequential operation of said first and second valves causes said cuttings to be moved from said accumulator to said combustion chamber.

5. The apparatus according to claim 4 including in addition cutthro retention means for retaining said cuttings while said cuttings are burning.

6. The apparatus according to claim 5 wherein said retention means comprises a mesh basket with means to empty said basket following the burning completion.

7. The apparatus according to claim 5 wherein said retention means comprises at least one metal plate mounted in said combustion chamber to receive said cuttings from said accumulator chamber, and includes means for removing said cuttings from said metal plate.

8. The apparatus according to claim 7 wherein means for removing said cuttings comprises at least one scraper blade mounted on a rotatable shaft in a scraping relationship to said at least one metal plate.

9. The apparatus according to claim 7 wherein said at least one metal plate comprises a plurality of vertically spaced metal plates, each of said plates having a discharge port therein, wherein said ports in adjacent plates lie in different vertical planes, respectively.

10. The apparatus according to claim 9, wherein means for removing said cuttings comprises a plurality of scraper blades mounted on a rotatable shaft, at least one of said blades being mounted on said shaft for each of said plurality of metal plates in scraping position thereto.

11. A method for disposing of pollutants in drill cuttings, comprising:
   - accumulating said cuttings;
   - moving said cuttings to a combustion chamber beneath the surface of a body of water;
   - burning said pollutants; and
   - releasing said cuttings into the water.

12. The method according to claim 11, wherein said moving step comprises the gravity dropping of said cuttings onto at least one metal plate.

13. The method according to claim 11, wherein said releasing step occurs beneath the surface of the water.

14. The method according to claim 13, comprising, in addition thereto, the step of sampling said released cuttings to ascertain adequate burning of said pollutants.

15. An incinerator for burning hydrocarbons from drill cuttings on an offshore barge, comprising:
   - a combustion chamber mounted on said barge;
   - an input port on said combustion chamber for feeding cuttings thereto; and
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7. A submerged discharge outlet connected to said combustion chamber, whereby said cuttings and exhaust gases from said combustion chamber can be discharged beneath the surface of the water.

16. An explosive-proof apparatus for burning hydrocarbons from drill cuttings, comprising:

8. A cuttings incinerator arranged to be submerged beneath the surface of a non-combustion supporting fluid; means for placing said cuttings into said incinerator; and means for displacing said cuttings from said incinerator after burning.

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