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METHOD OF AIR DRILLING

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This invention relates to the art of drilling wells. More particularly, it concerns the use of a gaseous drilling fluid in the rotary drilling of oil, gas and water wells.

In the rotary drilling of wells the conventional practice heretofore has been to use a liquid such as a clay base mud, an oil base mud or an emulsion mud as the circulating fluid. Normally the fluid is pumped through rotating drill pipe and out through an attached drill bit at the bottom of the well to cool the bit and carry the cuttings to the surface, by way of the annular space between the well wall and drill pipe. At the surface the cuttings are removed and the circulating fluid recycled to the pump inlet to repeat the procedure.

It has been found that by using a gaseous circulating fluid such as air, drilling rates and bit life are increased. Apparently this is due to the absence of a liquid drag on the rotating parts and the ability of the gaseous "drilling fluid" to remove the cuttings rapidly from the vicinity of the bit thereby preventing regrinding of the cuttings. Additionally, improved heat transfer is obtained by the increased circulation volume. In using a gaseous drilling fluid, the pump normally used for liquids is replaced by one or a multiplicity of compressors. The returning or exhaust gas from the well is blown into the atmosphere. In some areas a high pressure gas line from a nearby field is substituted for the compressors.

One limitation in the rotary drilling of a well with gas as the circulating fluid is the presence of a small quantity of extraneous or formation water in the well which causes the agitated cuttings to ball up and to adhere to the drill pipe and bit. The larger cuttings formed by this "balling up" effect become difficult to remove from such wells since the compressors are limited in the amount of pressure and velocity necessary to carry these moist cuttings out of the hole. Wet cuttings or shale also adhere and bridge between the exposed formation casing, and the drill pipe and bit forming mud rings that build up around the drill pipe. This acts as a wedge to prevent the rotation and subsequent sticking of the pipe when attempts are made to remove it from the well.

To overcome this, it has been heretofore proposed to inject finely divided solids into the gaseous circulating fluid. These solids are to combine with the moist cuttings to prevent this balling up. For example, finely divided hygroscopic or moisture adsorbing materials such as talc and calcium chloride, and a hydrophobic material such as silica powder have been proposed. From tests it appears the hygroscopic materials tend to increase the effect of balling, whereas hydrophobic silica powder has been classified as hazardous due to the dangers to the respiratory system when inhaled.

Accordingly, it is an object of my invention to provide a finely divided material which overcomes the objections of the prior art materials.

It is a further object of my invention to introduce into the circulating gas stream a finely divided oil soluble powder which is non-toxic to the respiratory system and which acts to coat the individual cuttings with a hydrophobic or oily surface to prevent sticking and "balling up" of cuttings when water is present.

It is a further object of my invention to introduce into the circulating gas stream a finely divided non-toxic oil soluble powder which is capable of coating the drill pipe, drill bit and exposed formations with a hydrophobic or

oily surface to prevent cuttings from sticking and collecting thereon.

It is still a further object of my invention to avoid the above-mentioned problems previously experienced in air drilling by introducing into the gas stream finely divided powders such as non-toxic metallic soaps.

In the carrying out of my invention, finely divided oil soluble metallic soaps, preferably in dry form, are injected by any well known system, e.g., a star feeder, which is capable of injecting solids into the circulating gas stream entering the well.

The term "finely divided metallic soaps" as used herein refers to metallic soaps which have a bulk density in the range of about 30 fluid ounces per pound up to about 200 fluid ounces per pound, and which are capable of producing a film or surface area in the range of 13,000 to 35,000 $cm.^2/gm.$ of soap used. For example, zinc stearate USP grade A has a bulk density of 140 fluid ounces per pound with about 24,600 $cm.^2/gm.$ of surface covering ability.

In practicing my invention it is usually preferred to inject about 30–40 pounds of metallic soap per hour of drilling. However, this may vary from as low as 10 pounds per hour to as much as 60 pounds per hour, depending upon the need and the capacity of the injection system.

It is to be noted, however, that the above characteristics and amounts to be injected depend on many varying factors. The most important factor is the amount of water associated with the bit cuttings. From actual field trials I have found that when water is being produced in quantities up to about two barrels per hour, the balling and sticking occurs. This is usually indicated by the amount of moisture in the discharge line. It is to be noted that laboratory mixing tests indicate that when 10 to 35 percent by weight of cuttings is water, the problem of balling and sticking occurs. Above a water production of about two barrels per hour or when 35 percent by weight of cuttings is water, mud is formed when agitated and other means are used to overcome the problem. These figures are approximations since additional factors such as the cutting size, amount and type, the quantity, humidity, and temperature of the gaseous circulation media will affect the amount of balling and sticking.

In actual operation it is preferred that the dry powder be injected and contacted with fresh and relatively dry cuttings and drill pipe surfaces prior to their contact with water. However, in some instances where larger amounts of water are present, it is preferable to inject solids which are premoistened for example by spraying with an organic water miscible solvent such as an alcohol, for example, methyl, ethyl, or isopropyl alcohol.

It may be preferred in some instances to inject the metallic soap as a solution, emulsion or dispersion in a volatile solvent such as gasoline, naphtha, toluene, or xylene. The solvent will evaporate leaving a hydrophobic film on the surfaces treated.

The metallic soaps contemplated by my invention are those that are usually formed either by direct combination or fusion of the oxide, hydroxide or carbonate of an alkaline earth metal with a carboxylic or fatty acid radical which can be in an oil or fat. The two components are mixed and heated, whereupon the glycerides split forming the metallic soap and glycerol. Another method for manufacturing metallic soaps is by mixing water solutions of a salt of the desired metal and the sodium salt of the fatty acid.

In general, I have found the oil soluble or water insoluble metallic soaps of the alkaline earth and heavy metals to be within the purview of my invention.

Specifically the soaps of calcium stearate, zinc stearate and aluminum octoate are preferred for preventing the "balling up" of cuttings. However, other metal soaps

which are oil soluble are within the purview of my invention. As used herein the term "oil soluble" refers to those metallic soaps which are soluble and/or dispersible in organic petroleum solvents, terpenes, organic oils and acids, coal tar solvents or addition agents. Due to the high air temperatures created by the compressors and deep well drilling other metallic soaps such as lithium stearate, which softens at about 200° C., will, in some instances, be more suited.

Other metals which are combined with acids to form the soaps generally include those of groups I–B and II–VIII of the periodic table. It is desirable to use the soaps of copper, magnesium, barium, mercury, cadmium, aluminum, titanium, tin, lead, vanadium, chromium, iron, nickel, cobalt, manganese. Suitable acids for making the soap may be the carboxylic acids such as, abietic acids, rosin, tall oil, etc., or fatty acids such as lauric, oleic, palmitic, ricinoleic and stearic acids.

It is not altogether understood how these metallic soaps operate to prevent the "balling up of cuttings." From laboratory experiments it appears that these finely divided particles act to form, either by attractive surface forces, or by fusion caused by heat and pressure, a hydrophobic or oily surface on each of the freshly cut particles. These same tests indicate that the surfaces of the drill pipe and bit are coated with the materials. The hydrophobic surfaces help to prevent individual bit cuttings from agglomerating and sticking to the drill pipe and well wall.

The success of the metallic soaps was first indicated in shallow well tests at a depth of approximately 30–250 feet. A water productive sand was situated directly above a long shale section. The amount of water being produced was not accurately determined, but it was estimated to be less than two barrels per hour, and in some instances as much as 0.5 barrel per hour. The input air volume, weight on bit, and rotary table speed were all maintained relatively constant, i.e., within the range of 230–275 cubic feet per minute, 6300 pounds, and 65 r.p.m. respectively. Beginning at approximately 30 feet a different chemical was added for each ten feet of hole drilled. In each case after the ten foot interval was reached, the drill pipe and bit were pulled and inspected to determine the effectiveness of the particular additive. The qualitative results are shown in Table I.

Table I

Additive	Evaluation While Drilling And Chemical Being Injected	Evaluation After Drilling Condition of Pipe and Bit
None	Lost returns, muddy water.	Difficult to pull, pipe and bit caked.
Water	do	Do.
Talc (powder)	No water, poor cuttings return.	Bit and pipe caked, bridge formed.
Calcium Chloride (pellets).	do	Do.
Graphite	Lost returns	Do.
Aluminum Stearate (powder).	Clear water, returns good.	No bridge, bit and pipe clear.
Aluminum Octoate (powder).	do	Do.
Hydrophobic Silica (powder).	Clear water, returns good (Toxic, crew must wear masks.)	Do.

These tests were followed by extensive field experiments of which the following examples will serve to illustrate the present invention, but are not intended to limit it.

EXAMPLE I

While drilling the Elk Ridge Well No. 1 in San Juan County, Utah, air was circulated as the drilling fluid. This was supplied by three compressors at a rate of 600 cubic feet per minute and at a maximum pressure of 300 p.s.i. The hole was reamed from 2,085 feet with a nine-inch bit. Water in unknown quantity, but estimated at less than two barrels per hour, was encountered at 2,090 feet. The operators were unable to ream ahead and an unsuccessful attempt was made to blow the hole dry. Zinc stearate was then injected for four hours at an average injection rate of 20 pounds per hour. The hole was reamed to 2,237 feet with air, chemical and cuttings returning to the surface. There was no free water, the cuttings were dry and the drill pipe and bit were clear. These conditions were continued to a depth of 2,442 feet with periodic injection of chemicals resulting in good returns. During this 358 foot interval (requiring seven hours) a total of 140 pounds of zinc stearate was injected.

EXAMPLE II

While conducting air drilling operations on the W. W. Carson No. 1 Well, Val Verde County, Texas, a water flow of approximately 0.3 barrel per hour was encountered at about 5,175 feet. (The water flow was indicated by the amount of moisture in the discharge line.) Due to the large amount of dry air being circulated (around 2,700 cubic feet per minute), the hole was kept dry without chemical injection. However, during "shutdown" periods the water and cuttings were sufficient to cause balling and sticking of the drill pipe. To prevent this, zinc and calcium stearates were injected into the hole before trips, i.e., preparing to pull the pipe out of the hole to change the bit or for surveys. Injection was continued during a reaming operation, and after trips until the humidity ratio indicated the hole was dry. During these operations there was no evidence of balling or sticking of the drill pipe.

In the above examples, the gas or air passed down through the drill pipe and up through the annular space between the drill pipe and the wall of the hole. It is to be understood, however, that the process of my invention likewise applies to reverse circulation drilling, that is, when the above procedures are reversed.

Since it is difficult to determine when the problem of "balling up" of cuttings will be encountered, it is preferred to inject small amounts of the metallic soaps continuously or intermittently during the drilling operation. However, if it is known that at only certain depths balling of cuttings will occur, then injection of the solids may be postponed until that depth is reached.

My invention can also be utilized in gaseous drilling when it becomes necessary to clear the well of cuttings by circulation of the gas without drilling. As shown in Example II, this is done frequently before and while the drill pipe is pulled (to change the bit or treat the well in some manner). Circulation of a gaseous fluid containing the metallic soaps of my invention can also be accomplished after the drill pipe is placed in the well, but prior to actual drilling. In some instances it is desirable to place the drill pipe and bit about one or two feet from the bottom of the well and circulate with a gaseous fluid containing metallic soaps.

Although I have described my invention with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the method and materials may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

I claim:

1. In a method of drilling a well in which a gas is used as the circulation fluid and wherein the rate of influx of aqueous formation fluids into the well bore is sufficiently high to interfere with the effective removal of cuttings from said well during the drilling thereof but said influx is not in excess of about 2 barrels per hour, the improvement which comprises injecting into said gas before it passes into said well, a finely divided solid nontoxic oil soluble metal soap derived from a metal selected from the group consisting of aluminum, magnesium, calcium, zinc and lithium, and from an aliphatic carboxylic acid having from about 8 to 18 carbon atoms.

2. The process of claim 1 in which the metal soap

employed is derived from aluminum and an aliphatic carboxylic acid having from about 8 to 18 carbon atoms.

3. The process of claim 2 in which the aluminum soap is aluminum octoate.

4. The process of claim 1 in which the metal soap employed is derived from magnesium and an aliphatic carboxylic acid having from about 8 to 18 carbon atoms.

5. The process of claim 1 in which the metal soap employed is derived from calcium and an aliphatic carboxylic acid having from about 8 to 18 carbon atoms.

6. The process of claim 5 in which the calcium soap is calcium stearate.

7. The process of claim 1 in which the metal soap employed is derived from zinc and an aliphatic carboxylic acid having from about 8 to 18 carbon atoms.

8. The process of claim 7 in which the zinc soap is zinc stearate.

9. The process of claim 1 in which the metal soap employed is derived from lithium and an aliphatic carboxylic acid having from about 8 to 18 carbon atoms.

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