Title: A METHOD AND APPARATUS FOR RECOVERING DRILLING MUD

Abstract: A method and apparatus for recovering spent drilling mud, the apparatus comprising a mixer (20) to mix flocculants with spent drilling mud to produce a mixture, heating said mixture with a heating apparatus (314) to produce a heated mixture, and separating drilling mud with a separating apparatus (330) from the heated mixture to produce separated drilling mud.
A METHOD AND APPARATUS FOR RECOVERING DRILLING MUD

The present invention relates to a method and apparatus for recovering drilling mud from spent drilling mud.

In the drilling of a borehole in the construction of an oil or gas well, a drill bit is arranged on the end of a drill string and is rotated to bore the borehole. A drilling fluid known as "drilling mud" is pumped through the drill string to the drill bit to lubricate the drill bit. The drill bit may be rotated by a downhole mud motor carried by the drilling assembly and/or by rotating the drill pipe with a rotary, power swivel, or a top drive. The drilling mud is also used to carry the cuttings produced by the drill bit and other solids to the surface through an annulus formed between the drill string and the borehole. The drilling mud contains expensive synthetic oil-based or water based lubricants and it is normal therefore to recover and re-use the used drilling mud, but this requires the solids to be removed from the drilling mud. This is achieved by processing the drilling fluid. The first part of the process is to separate the solids from the solids laden drilling mud. This is at least partly achieved with a vibratory separator, such as those shale shakers disclosed in US 5,265,730, WO 96/33792 and WO 98/16328. Other apparatus may be used in the processing of the solids laden drilling mud, such as centrifuges, hydrocyclones, settling tanks with weir systems, vortex dryers and heaters. In the processing of drilling mud, the drilling mud often needs to be stored temporarily in a buffer system before re-use. The buffer system comprises lined holes in the ground or tanks known as mud pits. Pipes are arranged to flow drilling mud into
the pits and out from the pits when drilling mud is required in the construction, maintenance and repair of the well. The mud pit may also comprise a stirrer or agitator to help maintain chemicals, particles and/or lost circulation material in the mud in suspension. The mud pit is preferably used to buffer processed drilling mud, but may also be used to buffer solids laden drilling fluid. After a period of use, mud pits solids and other detritus build up on the bottom and walls of the mud pit and require cleaning.

Drilling mud can provide downhole hydrostatic pressure that is greater than the formation pressure to control the pressure of fluid in the earth formation being drilled and to avoid blow outs. The drilling mud may drive a downhole drilling motor and it also provides lubrication to various elements of the drill string. Commonly used drilling fluids are either water-based or oil based fluids. They can also contain a variety of additives which provide desired viscosity, lubricating characteristics, heat, anti corrosion and other performance characteristics. In certain aspects, the drilling mud is, initially, a suspension or solution of a suitable agent with a specific density, viscosity and chemical composition suitable for a particular geological stratum. These agents can include bentonite, oil, lignosulphonates and biopolymers, i.e. polysaccharides. During drilling, the fluid becomes laden with material from the ground, drilled cuttings, and debris and a mud results, its viscosity, density and composition varying as the mud circulates. Consequently, the viscosity, density and concentration in respect of minerals increases constantly and finally these properties can render the mud no longer suitable for operation. It is
then necessary to discharge at least some of the mud and replace it by new fluid. In most cases, this renewal requires prior separation of solids dispersed in the mud. If the solids are inadequately separated, the liquid generally has a very high density, so that a large quantity of fresh fluid has to be added to dilute it suitably.

The prior art discloses a wide variety of drilling fluid pumping, treatment, and recovery systems, apparatuses, and methods, including, but not limited to, the disclosures in U.S. Patents 6,944,547; 6,918,453; 6,802,378; 6,533,946; 6,193,070; 6,050,348; 5,853,583; 5,465,799; 5,310,285; 5,129,468; 4,995,465; 4,913,585; 4,854,397; 4,548,525; 4,192,392; 3,658,138 (all said patents incorporated fully herein for all purposes).

U.S. Patent 4,353,803 discloses an admixture of waste (oil well) drill cuttings, drilling fluid and by products of rotary drilling that are separated into good quality water and high density solids by chemical and mechanical means in original earthen mud storage and/or reserve pits. The treatment produces two useful benefits: (1) good quality water (useful for agriculture or for drilling a new well) is recovered, and (2) resulting concentrated solids are of such a high density that the land area occupied by and containing such dewatered solids can be immediately levelled and restored to the same use it had before the well was drilled. The effect is a reduction in energy of at least 75 to 85 percent over some methods of hauling whole mud off by trucks to a commercial waste disposal site. In one aspect this patent discloses a flocculants useful for waste drilling fluid reserve pit treating wherein the reserve pit contains an aqueous spent oil well drilling mud including an anionic
colloid selected from the group consisting of drilling fluid grade lignosulfonate and alkaline soluble lignite, the flocculants consisting essentially of from 24 to 49 parts by weight of aluminum sulfate per part by weight of polyacrylamide homopolymer having from 130 to 500 pendant amide groups per pendant carboxylic acid or carboxylic acid salt group and having a molecular weight in the range of from 10,000 to 5 million.

U.S. Patent 4,482,459 discloses a continuous process for the reclamation of a slurry of waste drilling mud fluids and water normally resulting from drilling operations. The process comprises the steps of conducting the drilling mud slurry to a slurry surge tank for liquid solid separation by chemical and physical methods. The mud slurry is subjected to a primary solids separation unit after pH adjustment is used to initiate coagulation and an organic flocculants is added to aid flocculation of the solids. The water is then subjected to a secondary solids removal, and the solids recovered are reintroduced in the primary solids separation unit. Thereafter the water obtained from the secondary solids removal is then subjected to a chemical oxygen demand reduction unit having a carbon adsorption unit or reverse osmosis membrane units therein to remove organic matter or dissolved solids to produce water meeting environmental discharge requirements. The solids removed from the primary solids separation unit are converted to a cake meeting leachate requirements for other beneficial use. In one aspect the patent discloses a method of rendering a waste drilling fluid slurry from oil wells containing cuttings, formation fluid solids and liquids and the like, safe for environmental discharge both in a liquid and solid cake
state comprising the steps of: (a) conducting the uphole drilling fluids to a continuous flow process having a slurry surge tank for chemical conditioning by addition of an inorganic acidic coagulant permitting settling and thickening; (b) subjecting the thickened mud slurry under flow from step (a) thereafter to a primary solids separation unit where an organic flocculants of the group of polyacrylamides is added to aid flocculation of the solids and from which solids of less than 50% moisture content and water are produced; (c) subjecting the water from (b) to a secondary solids removal unit, chemically conditioning and reintroducing the solids recovered back to the primary solids separation unit; (d) subjecting the water obtained from the secondary solids removal step (a) to a chemical oxygen demand reduction unit having a carbon adsorption unit for removal of organic substances or a reverse osmosis unit for removal of organic substances and dissolved solids including chlorine compounds to meet environmental discharge requirements; (e) removing the treated primary solids from step (b) consisting of an environmentally compatible cake meeting environmental leachate requirements for disposal as landfill on or off the drill site.

U.S. Patent 4,913,585 discloses methods in which waste drilling mud is stabilized for earthen burial. The waste drilling mud may be treated by flocculating, aggregating, agglomerating and dewatering the waste drilling mud and separating out free water. The free water may be reused or disposed of in a disposal well. The thickened, dewatered drilling mud solids may be further treated with a water absorbing binder to produce a residue which has sufficient bearing strength to support an earthen overburden and may be disposed of by
burial. Suitable flocculating, agglomerating and dewatering polyelectrolytes may be used, including polyacrylamides, quarternary amine polymers and mixtures thereof. The water absorbing binders may include inorganic and organic materials, such as natural and synthetic water absorbing gums, polymers and inorganic colloidal absorbers. In one aspect the patent discloses a method of treating a waste drilling mud residue having drilling mud solids suspended in an aqueous base comprising adding flocculating polymer to the waste drilling mud, the flocculating polymer consisting essentially of a mud solids flocculating polymer selected from the group consisting of acrylamide polyelectrolyes, quarternary amine polymers and mixtures thereof, the mud solids flocculating polymer being effective to agglomerate the drilling mud solids, flocculate the agglomerate drilling mud solids and separate free water from the flocculated drilling mud solids to produce a concentrated residue of wet drilling mud solids having a reduced volume and mass.

U.S. Patent 5,422,012 discloses a method of removing suspended solids from drilling fluid includes preparing a dilute solution of flocculants and water, delivering a batch of the drilling fluid into the solution and agitating the mixture. The solids flocculate and then separate readily leaving a generally clear water layer on top of a solids layer. The solids are removed from the mixture by delivering them to a solids liquid separator such as a shale shaker where the solids are discarded and the water is reclaimed and reused. Preferably, drilling mud is treated to remove solids while a well is being drilled and the reclaimed water is used in subsequent drilling operations. In one aspect the patent discloses a
method of removing drilled solids from drilling fluid, comprising providing a tank partially filled with a flocculants water solution substantially free of suspended drilled solids; then adding drilling fluid, including drilled solids and water, to the tank and flocculating the drilled solids; then delivering a mixture of the flocculated drilled solids and the water to a separator and separating the mixture into a first stream comprising mainly flocculated drilled solids and a second stream comprising mainly water; and collecting the first stream.

U.S. Patent 6,193,070 discloses a solids separation system used to separate solids, such as cuttings from drilling fluids used in well drilling operations. The system includes a settling tank having transverse baffles defining a fluid receiving chamber, a fluid output chamber and one or more intermediate chambers. Fluid introduced into the fluid receiving chamber can flow in a sinuous path through apertures in the baffles to the fluid output chamber. Solids settle to the bottom of the settling tank. A material conveyor, preferably an auger, extends along a bottom surface of the settling tank to an outlet port in the fluid receiving chamber. A centrifuge is connected to the output port to receive fluid in which solids have been concentrated. Fluid output from the centrifuge is reintroduced into the settling tank. The apparatus and method of the invention permit a single centrifuge to be used to handle a higher volume of fluid than is possible with conventional methods and apparatus. This provides significant cost savings. In one aspect the patent discloses apparatus for removing solids from fluids, the apparatus comprising: (a) a settling tank comprising: (i) a fluid receiving chamber at a first end
of the tank; (ii) a fluid output chamber at a second end of the tank; (iii) a plurality of transverse apertured baffles extending across the tank between the fluid receiving chamber and the fluid output chamber, the baffles defining one or more intermediate chambers between the fluid receiving chamber and the fluid output chamber; (iv) a material conveyor extending along a lower side of the tank to an outlet port at the first end of the tank, the material conveyor comprising a motor driving the material conveyor to carry materials in a direction toward the outlet port; and, (v) a fluid outlet at the second end of the tank; and, (b) a centrifuge comprising: (i) an inlet in fluid communication with the outlet port of the settling tank; and, (ii) a fluid outlet in fluid communication with the fluid receiving chamber of the settling tank.

U.S. Patent 6,533,946 discloses an apparatus for cleaning and recycling slurry such as well drilling slurry or mud, which has an inlet for receiving a supply of drilling slurry contaminated with particulates; first screening means for coarse filtering the slurry; a slurry tank, with mixing means within said tank for mixing slurry filtered by the first screening means; an outlet conduit for discharging slurry from the tank; a cyclonic separator for separating the slurry received from the tank into a first stream containing relatively coarse particulates, and a second stream containing relatively fine particulates; a second, fine, screening means for receiving the first stream and removing particulates therefrom, and discharging the resulting screened fluid into the tank; a discharge conduit for receiving the second stream from the cyclonic separator, and directing the stream back into the tank, and into a discharge
outlet for reuse for forming a usable slurry; pump means for cycling the slurry through the system on a continuous basis; and control means for controlling the operation of the system.

In accordance with the present invention, there is provided a method for recovering drilling mud from spent drilling mud, the method comprising the steps of mixing flocculants with a spent drilling fluid to produce a mixture, heating the mixture to produce a heated mixture, and separating drilling mud from the heated mixture to produce separated drilling mud.

Preferably, the flocculants is mixed with a fluid to produce flocculants in fluid and mixing the flocculants in fluid with the spent drilling mud to produce the mixture. Advantageously, the fluid is water. Preferably, the flocculants is present in the flocculants in fluid at between 0.00125% and 0.5% of the total volume the flocculants in fluid. Advantageously, the flocculants is present in the flocculants in fluid at 0.0025% of the total volume the flocculants in fluid.

Preferably, the mixture comprises by volume between 5% to 20% flocculants in fluid and between 80% and 95% spent drilling mud. [Preferably, the ratio if flocculants to water and drilling mud is between 5 and 10 to 90 to 95. Preferably, the flocculants in fluid is held in a tank before being mixed with the spent drilling mud. Advantageously, the flocculants in fluid in agitated with an agitator in the tank.

Preferably, the method further comprises the step of heating is effected by injecting steam into the mixture. Advantageously, the mixture is in a flow conduit and the steam is injected into the mixture within the flow conduit. Advantageously, the mixture is in a pressure
vessel and the steam is injected into the mixture within the pressure vessel.

Preferably, the mixture is heated to a temperature between 70 and 375 Celsius (160 F and 705 F).

Advantageously, the mixture is produced in a mixing apparatus, the mixing apparatus comprising a high speed mixer, the method further comprising the step of producing the mixture in the high speed mixer.

Advantageously, no emulsifier is added to the mixture.

Preferably, the spent drilling mud is pumped from an active rig mud system the method further comprising feeding separated drilling mud back to the active rig mud system. Preferably, the active rig mud system circulates separated drilling mud down through a drill string in a wellbore bore to a drill bit and up through an annulus formed between the drill string and the wellbore, the separated drilling mud now spent, carrying solids therein and other contaminants.

Advantageously, the method further comprises the step of separating is effected with centrifuge apparatus. Preferably, the centrifuge apparatus produces a stream of recovered drilling fluid in which the ratio by volume of drilling fluid to water is at least 90 to 10.

Preferably, the method further comprises the step of emulsion testing the separated drilling fluid to determine if it is acceptable for re-use. Advantageously, the spent drilling mud comprises solids, the method further comprising the step of processing separated drilling fluid to remove solids with a largest dimension between 3 microns and 30 microns. The separation apparatus preferably comprises at least one of: a centrifuge; a shale shaker; a settling tank; a weir
apparatus; and a hydrocyclone.

Preferably, the method further comprises the step of feeding the heated mixture to a tank in which any solids in the heated mixture settle out and flowing the mixture without the solids. Preferably, this step occurs before the heated mixture is processed with further separation apparatus, such as a centrifuge, shale shaker or hydrocyclone.

Advantageously, the separated drilling mud is continuously separated from the mixture.

The present invention also provides an apparatus for recovering spent drilling mud, the apparatus comprising a mixer to mix flocculants with spent drilling mud to produce a mixture, heating the mixture with a heating apparatus to produce a heated mixture, and separating drilling mud with a separating apparatus from the heated mixture to produce separated drilling mud.

The present invention discloses, in at least certain aspects, a system for recovering valuable drilling fluid, (e.g., but not limited to, clean oil, diesel fuel, synthetic oil, olefins) the system including apparatus for preparing a flocculants mixture; apparatus for mixing the flocculants mixture with spent (used) drilling fluid containing contaminants (e.g. drilled cuttings, debris); and apparatus for heating the resulting mixture of spent drilling fluid and flocculants mixture. In certain aspects the resulting mixture, following heating, is further processed to produce usable drilling fluid.

In certain aspects, the flocculants mixture contains a relatively small amount of flocculants by volume compared to the total volume of spent drilling fluid being treated plus flocculants mixture. In certain particular aspects, the amount of flocculants ranges, by
volume as a percent of the total volume, between 0.00125% and 0.5% and, in one aspect, is 0.0025%.

In certain aspects, heating of the spent-fluid/flocculants mixture is achieved by heating the mixture to between 160°F to 400°F (70 to 200°C). In one particular aspect, such heating is achieved by injecting live atmospheric steam into the mixture, either into a conduit through which the mixture is passing or in a pressurized vessel.

In certain aspects, the mixture, following heating, is processed further to separate fluid from solids. In one aspect, such separation is done by centrifuge apparatus. In one aspect, the centrifuge apparatus produces solids which are discharged and a liquid mixture which is either a mixture with acceptable characteristics to be re-introduced into a rig mud system or a mixture which is fed to settling apparatus which produces recovered fluid (e.g. oil) which can be re-used and water. Optionally, the heated mixture is fed to a holding tank prior to centrifugation, in which, in one aspect separative settling occurs. Optionally, the solids discharged from the centrifuge apparatus are treated thermally and fluids are recovered thereby.

In one particular aspect the fluid (e.g. recovered oil) produced by separation following heating is tested with an emulsion stability testing apparatus to determine if the fluid is acceptable for re-emulsifying (if necessary) for re-use as drilling fluid. Such systems and methods in which a mixture of flocculants material and spent mud is heated to facilitate separation of acceptable fluid; and such systems and methods in which a relatively low amount of flocculant, by volume, is used.
For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a schematic view of a system in accordance with the present invention;

Figure 2 is a schematic view of a system in accordance with the present invention;

Figure 3 is a schematic view of a system in accordance with the present invention; and

Figure 4 is a schematic view of a system in accordance with the present invention.

Figure 1 shows a system 10 in accordance with the present invention with a make-up apparatus 12 for producing a mixture of flocculants and water. In certain aspects, the amount of flocculants, by volume, in the resulting mixture is between 0.00125% and 0.5%, and, in one particular aspect, is 0.0025%. The apparatus 12 includes a tank 14 into which are fed (pumped and metered) water (line 16) and flocculants (in aqueous solution) in line 18. Optionally, an agitation apparatus 15 agitates the material in the tank 14. A metering pump 19 pumps the resulting water/flocculants mixture to mixing apparatus 20.

As spent drilling fluid mixture containing drilling fluid (oil-based or water-based) and contaminants from a mud source 24, such as a mud pit, used in wellbore operation (e.g. drilling, reaming) which has drilling fluid and contaminants (drilled cuttings and/or debris) therein is pumped by a pump 22 from the mud source 24 to the mixing apparatus 20. In certain aspects, the material is mixed for between 2 and 15 minutes. In certain aspects, the resulting mixture is by volume, between 5 to 20% water. The resulting mixture of spent drilling fluid
and water/flocculants mixture is pumped to heater apparatus 20. The heater apparatus 20 heats the mixture, e.g. to a temperature between 70 to 95 Celsius (160 F to 200 F) (or up to 200 to 375 Celsius (400 F up to 705 F)) to decrease viscosity and/or break down emulsion.

Following the heating step, the heated resulting mixture is sent from the heater apparatus 30 for further processing.

The mixing apparatus 20 (as may be true for any embodiment of the present invention) is, in one aspect, a high speed (500 rpm to 19,000 rpm) high shear mixer; and, in one particular aspect, is a 10,000 rpm mixer. As an example, and not by way of limitation, a commercially available TURRAX (trademark) mixer is used.

In certain particular aspects the metering pump 19 (as may be true for any embodiment of the present invention) pumps the water/flocculants mixture to the mixing apparatus at between 38 and 190 litres per minute (10 and 50 gallons per minute) and, in one particular aspect, at 114 litres per minute (30 gallons per minute).

In one aspect, the mud source 24 is a mud feed tank. In other aspects the mud source 24 is a direct feed from an active rig mud system (as may be true for any embodiment of the present invention).

As may be true with any system and method in accordance with the present invention, including those of Figures 2 to 4, acceptable recovered fluid from further processing apparatus 30 may be fed back in a continuous process (see dotted line, Figure 1) to the mud source 24 (which may be an active rig mud system).

In the embodiments of Figures 2 to 4 numerals as in Figure 1 indicate like parts or apparatuses.

Figure 2 shows a system 100, like the system of
Figure 1, with a centrifuge apparatus 102 which receives the mixture following heating. The centrifuge apparatus 102 produces separated solids (line 104) which are discharged to storage and/or disposal apparatus 106, and a stream of fluid 110 which contains drilling fluid (e.g. recovered oil) and water. The stream 110 can be further processed, fed to storage, used as fuel, or re-introduced to an active rig mud system. In certain aspects, the centrifuge apparatus 102 produces a stream of recovered oil in which the ratio by volume of oil to water is at least 90 to 10, in one aspect a ratio of 95 to 5.

Figure 3 shows a system 200 in accordance with the present invention which has an emulsion stability testing apparatus 202. A further processing apparatus 204 produces separated solids (line 206) and a stream of fluid 208 (e.g. recovered oil). The emulsion stability testing apparatus tests the emulsion stability of the fluid in the stream 208. In one aspect after emulsion stability testing, a recovered oil/water mixture is further emulsified to maintain the solubility of all components when mixed together. The ES (emulsion stability) number in volts refers to the electrical conductivity of the mixture. Pure oil is a non-conductor and will have a high ES value. Water is a good conductor and will have a low ES value. An ES value of 0-150 volts means the mixture is a weak emulsion. A value of 1000 means the mixture is strongly emulsified. This information indicates a measure of compatibility of the material with water. If the emulsion level is unacceptable, the material can be recycled. If the level is acceptable, the material can be fed to an active rig mud system. In some cases a trial-and-error procedure is used to adjust this level until suitable stability is
achieved, i.e., until the material does not separate into layers.

Figure 4 shows a system 300 in accordance with the present invention in which the heater apparatus is a steam injection system 310 which includes a steam generator 312 and steam injector apparatus 314 for injecting live steam into the spent-mud/flocculants mixture from the mixing apparatus 20. In one aspect, live steam is injected into a line or conduit conveying the mixture to heat the mixture e.g. to between 70 and 205 Celsius (160 F and 400 F) and, in one case, to between 70 and 93 Celsius (160 F and 200 F). In one particular aspect, the steam is injected at a pressure up to 220 bars (3210 psia) at a temperature up to 375 Celsius (705 F). In one aspect, the spent fluid/flocculants mixture is heated with the live injected steam in a vessel in which the total pressure is maintained between atmospheric pressure and an upper pressure (in one aspect, an upper pressure of up to 220 bars (3210 psia)).

Optionally, the heated mixture is fed to a holding tank 322 and then to a centrifuge 330. The tank 322 can provide gravity settling of materials and settled solids can be removed in a line 323. With no tank 322 present, the heated mixture is fed directly to the centrifuge 330.

The centrifuge 330 (or centrifuges if a plurality of centrifuges are used) produces separated solids in a line 332 which are fed to storage and/or disposal 334 and a stream of fluid 336.

The stream of fluid 336 which is, e.g. recovered fluid, e.g. recovered oil, flows either to an active rig mud system 340 or to a settling apparatus 350. Valves 342, 352 selectively control flow to these apparatuses.
and systems.

The settling apparatus 350 includes a settling tank 354 from which separated water exits in a line 356 and recovered fluid, e.g. oil, flows out in a line 358. The recovered fluid may flow to the active rig mud system or to storage or disposal. Optionally, in one particular aspect, the spent-mud/flocculants mixture is fed into a pressure vessel 360 (shown in dotted lines, Figure 4) and the live steam is injected into the pressure vessel. In one aspect, the pressure in the pressure vessel is maintained between atmospheric pressure and a pressure of 3.5 bars (50 psi gauge).

Any system in accordance with the present invention, including the embodiments of Figures 1 to 4, can be used to separate fine particulate solids, e.g. solids ranging in a largest dimension between 3 to 30 microns, from spent drilling fluid. Flocculants changes these fine particles to facilitate their agglomeration and, thus, their separation from the spent fluid.

In certain aspects, and in certain aspects of each of the embodiments of Figures 1 to 4, no demulsifier is added at any point in the methods. Demulsifiers can make it more difficult to reconstitute drilling fluid and can also necessitate the use of additional stabilizing chemicals. In certain aspects, any embodiment in accordance with the present invention, including those of Figures 1 to 4, obtain a recovered oil fluid in which the ratio of recovered oil to water is 90 to 10 or greater. This minimizes the amount of fresh oil which must be added to produce a satisfactory re-usable reconstituted oil based fluid.

The flocculants used in embodiments of the present invention may be any suitable commercially available
flocculant; for example those disclosed in U.S. Patents 6,193,070; 5,422,012; and 4,913,585.

The present invention discloses, in at least certain aspects, methods for recovering drilling fluid from a mixture containing drilling fluid and other components, the mixture resulting from a wellbore operation including the pumping of drilling fluid, the methods including: producing a mixture of flocculants with a spent drilling fluid; the spent drilling fluid containing drilling fluid and contaminants; heating the mixture; and separating drilling fluid from the mixture. Such methods may include one or some, in any possible combination, of the following: wherein the heating is effected by injecting steam into the mixture; wherein the mixture is in a flow conduit and the steam is injected into the mixture within the flow conduit; wherein the mixture is in a pressure vessel and the steam is injected into the mixture within the pressure vessel; wherein the mixture is heated to a temperature between 160 F and 705 F; wherein the mixture is produced in a mixing apparatus, the mixing apparatus comprising a high speed mixer, the method further including producing the mixture in the high speed mixer; adding no emulsifier to the mixture; wherein the flocculants is in a combination of flocculants and water, the flocculants present at between .00125% and 0.5% of the total volume of the combination; wherein the flocculants is present as 0.0025% of the total volume of the combination; wherein the water is present by volume between 5% to 20%; wherein the spent drilling fluid is pumped from an active rig mud system, the method further including feeding separated drilling fluid back to the active rig mud system; wherein the separating is effected with centrifuge apparatus; wherein the centrifuge
apparatus produces a stream of recovered drilling fluid in which the ratio by volume of drilling fluid to water is at least 90 to 10; emulsion testing separated drilling fluid to determine if it is acceptable for re-use; wherein the contaminants include solids, the method further including processing separated drilling fluid to remove solids with a largest dimension between 3 microns and 30 microns; feeding the heated mixture to a tank in which solids in the mixture settle out and are removed before the separating step; and/or continuously separating drilling fluid from the mixture.

The present invention discloses, in at least certain aspects, a method for recovering drilling fluid from a mixture containing drilling fluid and other components, the mixture resulting from a wellbore operation including the pumping of drilling fluid, the method including: producing a mixture of flocculants with a spent drilling fluid, the spent drilling fluid containing drilling fluid and contaminants; heating the mixture; separating drilling fluid from the mixture; wherein the heating is effected by injecting steam into the mixture,; wherein the mixture is heated to a temperature between 160 F and 705 F,; wherein the mixture is produced in a mixing apparatus, the mixing apparatus including a high speed mixer, the method further including producing the mixture in the high speed mixer; wherein no emulsifier is added to the mixture; wherein the flocculants is in a combination of flocculants and water, the flocculants present at between .00125% and 0.5% of the total volume of the combination; wherein the water is present by volume between 5% to 20%; wherein the separating is effected with centrifuge apparatus; wherein the centrifuge apparatus produces a stream of recovered
drilling fluid in which the ratio by volume of drilling fluid to water is at least 90 to 10; and wherein drilling fluid is continuously separated from the mixture.

The present invention discloses, in at least certain aspects, a system for recovering drilling fluid from a spent drilling fluid mixture, the spent drilling fluid mixture including drilling fluid and contaminants, the system including: a tank apparatus for mixing water and flocculants to produce a water-flocculants mixture; a mixing apparatus for receiving and mixing the water-flocculants mixture with spent drilling fluid to produce a drilling fluid mixture; heating apparatus for receiving and heating the drilling fluid mixture to produce a heated drilling fluid mixture; and separation apparatus for receiving the heated drilling fluid mixture and for separating drilling fluid from the drilling fluid mixture.

The present invention discloses, in at least certain aspects, a method for wellbore operations including: pumping drilling fluid with an active rig mud system into and from a wellbore; pumping spent drilling fluid from the wellbore with the active rig mud system to a mixer; pumping a water-flocculants mixture to the mixer; mixing with the mixer the spent drilling fluid and the water-flocculants mixture producing a primary mixture; heating the primary mixture; feeding heated primary mixture to separation apparatus; with the separation apparatus producing re-usable drilling fluid separated from the primary mixture; and feeding the separated re-usable drilling fluid back to the active rig and system for re-use
CLAiMS:
1. A method for recovering drilling fluid from spent drilling mud, the method comprising the steps of mixing flocculants with a spent drilling fluid to produce a mixture, heating said mixture to produce a heated mixture, and separating drilling mud from the heated mixture to produce separated drilling mud.
2. A method in accordance with Claim 1, wherein said flocculants is mixed with a fluid to produce flocculants in fluid and mixing said flocculants in fluid with said spent drilling mud to produce said mixture.
3. A method in accordance with Claim 2, wherein said flocculants is present in said flocculants in fluid at between 0.00125% and 0.5% of the total volume said flocculants in fluid.
4. A method in accordance with Claim 3, wherein said flocculants is present in said flocculants in fluid at 0.0025% of the total volume said flocculants in fluid.
5. A method in accordance with any of Claims 2 to 4, wherein said mixture comprises by volume between 5% to 20% flocculants in fluid and between 80% and 95% spent drilling mud.
6. A method in accordance with any of Claims 2 to 5, wherein said fluid is water.
7. A method in accordance with any preceding claim, wherein the step of heating is effected by injecting steam into said mixture.
8. A method in accordance with Claim 7, wherein said mixture is in a flow conduit (314) and the steam is injected into the mixture within the flow conduit (314).
9. A method in accordance with Claim 7 or 8, wherein said mixture is in a pressure vessel (360) and the steam is injected into the mixture within the pressure vessel.
10. A method in accordance with any preceding claim, wherein the mixture is heated to a temperature between 70 and 375 Celsius (160 F and 705 F).

11. A method in accordance with any preceding claim, wherein said mixture is produced in a mixing apparatus, the mixing apparatus comprising a high speed mixer (20), the method further comprising the step of producing said mixture in said high speed mixer (20).

12. A method in accordance with any preceding claim, wherein no emulsifier is added to said mixture.

13. A method in accordance with any preceding claim, wherein, the spent drilling mud is pumped from an active rig mud system (202), the method further comprising feeding separated drilling mud back to the active rig mud system (202).

14. A method in accordance with any preceding claim, wherein the step of separating is effected with centrifuge apparatus.

15. A method in accordance with Claim 14, wherein the centrifuge apparatus (102) produces a stream of recovered drilling fluid in which the ratio by volume of drilling fluid to water is at least 90 to 10.

16. A method in accordance with any preceding claim, further comprising the step of emulsion testing said separated drilling fluid to determine if it is acceptable for re-use.

17. A method in accordance with any preceding claim, wherein the spent drilling mud comprises solids, the method further comprising the step of processing separated drilling fluid to remove solids with a largest dimension between 3 microns and 30 microns.

18. A method in accordance with any preceding claim,
19. A method in accordance with any preceding claim, wherein said separated drilling mud is continuously separated from said mixture.

20. An apparatus for recovering spent drilling mud, the apparatus comprising a mixer (20) to mix flocculants with spent drilling mud to produce a mixture, heating said mixture with a heating apparatus (314) to produce a heated mixture, and separating drilling mud with a separating apparatus (102) from the heated mixture to produce separated drilling mud.
INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/050896

A. CLASSIFICATION OF SUBJECT MATTER

INV. E21B21/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B BOID

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category* Citation of document, with indication, where appropriate, of the relevant passages Relevant to claim No

X WO 2006/110691 A (MI LLC [US])
19 October 2006 (2006-10-19)
page 7, line 11 - page 12, line 13; figure 4
the whole document ----- 1-20

A WO 2006/110675 A (MI LLC [US])
19 October 2006 (2006-10-19)
the whole document ----- 1,20

A US 4 810 393 A (GUINARD PAUL [FR])
7 March 1989 (1989-03-07)
the whole document ----- 1,20

Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents
'A' document defining the general state of the art which is not considered to be of particular relevance
'E' earlier document but published on or after the international filing date
'L' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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'P' document published prior to the international filing date but later than the priority date claimed
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'X' document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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'*' document member of the same patent family

Date of the actual completion of the international search
3 March 2009

Date of mailing of the international search report
11/03/2009

Name and mailing address of the ISA/
European Patent Office, P B 5818 Patentaan 2
NL - 2280 HV Rijswijk
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Fax (+31-70) 340-3016

Authorized officer
van Berlo, Andre

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<th>Relevant to claim No</th>
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<td>US 6 162 284 A (MITCHELL BRYCE [CA] ET AL) 19 December 2000 (2000-12-19) A steam line 106 runs through the compartments of the tank and may be activated in cold weather operations to prevent the liquid in the tank from freezing. the whole document</td>
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