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METHOD OF DRILLING

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This invention relates to the art of earth boring and more particularly to improvements in the rotary drilling of oil and gas wells.

As is well known in the art, in the operation of a rotary drilling rig, a drilling fluid or mud is pumped downwardly through the drill stem, passes through holes in the bit, washes over the cutting faces of the bit and rises to the surface through the annular space surrounding the drill stem, this annular space approximating the amount by which the diameter of the bit exceeds the diameter of the drill stem. Among the functions of the drilling fluid are the sealing of the walls of the hole, lubrication of the bit, carrying the cuttings from the bit to a point outside of the hole, prevention of the settling of the cuttings and the consequent seizure of the bit, and supplying a static head sufficient to withstand the back-pressure of gas, water or oil encountered in the drilling.

In order to increase the weight of an oil well drilling mud sufficiently to overcome pressures encountered during boring, which would blow the fluid from the hole, it has heretofore been proposed to add to the mud weighting agents such as hematite, barytes and similar substances. To keep such weighting agents in suspension it is necessary to employ a suspending agent, and for this purpose certain types of clays have been used. These clays also have some value in sealing the walls of the drill hole, but from the standpoint of sealing the walls they leave much to be desired.

The problem of sealing the drill hole to prevent egress of the drilling fluid from the hole may be said to have three principal requirements: first, a gradation in particle size of materials much the same as is required of concrete aggregate, except that here the particles are smaller; second, a material which may be considered as colloidal jelling material to fill up the ultimate pores in the wall and to act as a binder; and third, the accomplishment of the above to produce a thin wall in order to prevent the sticking of the drill pipe and bit. In present practice, an ordinary mud will form a seal holding several thousand pounds of pressure, but the thickness ranges from one inch upward. The disadvantage of this will be seen when it is considered that a four inch drill stem will be used for a seven inch hole. Further, the thick wall is continually being knocked off by the eccentrically rotating pipe, thus destroying the seal. Certain colloidal clays combined with other formational mud in the drill hole will form an equally good seal with a thickness of one-sixteenth of an inch. Obviously, this is highly desirable. However, there is a limit to the sealing power of the inorganic colloids now used. Further, the materials that may be used for sealing purposes in the present art must be low in cost, because of the large amount required to condition an entire drilling system, the size of which will approximate 1,000 barrels. Losses of fluid with the settled cuttings and from seepage increase the amount of material required.

Among the objects of the present invention is the provision of a new and improved method of sealing the walls of drill holes in oil and gas wells and other types of earth bores. A further object of the invention is the provision of a new and improved method of drilling in a circulatory oil well drilling system, that is, a system in which a drilling fluid is continuously circulated in the drill hole. Another object of this invention is to provide a means of using materials for sealing and suspending purposes in oil well drilling fluids, which materials would be far too expensive to use according to the present art. Other objects will appear hereinafter.

In accomplishing these objects in accordance with this invention, a slug or segment of a wall sealing material is inserted in an oil well drilling fluid circulating system. This material is preferably a solution of cellulose or what may more properly be called a colloidal solution of cellulose. The cellulose or cellulose hydrate exists in minute colloidal size particles, and when properly precipitated in the walls of the hole will form a rubber-like seal. The preferred type of cellulose solution for this purpose is a salt solution of cellulose, as, for example, a zinc chloride solution. Thus, a solution of zinc chloride in water containing from 30% to 50% by weight of zinc chloride will dissolve at the temperature of boiling water, up to 10% of cellulose to produce a highly viscous gelatinous mixture which is peculiarly adaptable for use in the drilling of oil wells with rotary drills. When this solution is diluted with water or with an ordinary drilling fluid made from water and clay, with or without the addition of weighting agents, the cellulose will precipitate on the sides of the drill hole.

In accordance with the present invention, it has been found to be unnecessary to mix the cellulose solution with the drilling fluid, but on the other hand, more desirable to add a segment of the cellulose solution between segments of drilling fluid. The desirability of this procedure is shown by the fact that a 5 per cent solution of

cellulose and zinc chloride is very viscous and would not be desirable as a complete mud system due to the necessity of keeping it hot, but the precipitate from this solution forms a desirable rubber-like compound. On the other hand, a 2 per cent solution of cellulose in zinc chloride is a satisfactory fluid to use for the drilling system, but when precipitated forms more of a curdy type of precipitate which is not as desirable as is the rubber-like precipitate. As a further feature of the invention the segments of cellulose solution are separated from the segments of drilling mud by buffer segments which have no substantial action either on the drilling mud or on the cellulose solution.

In practicing the invention, two separate tanks may be connected with the pump intake of the rotary drilling rig. Ordinarily in the usual rotary drilling circulatory system, the drilling mud is pumped from a suction pit down into the hole, through the inside of the stem, then through the bit, up the outside of the stem between the stem and the hole and into a settling pit from whence the drilling fluid is passed into the suction pit and circulated. This operation may be varied somewhat, for instance, by removing some of the heavier particles as they come from the hole by means of vibrating screens, but the general principles of circulation are the same in practically all drilling units.

In the present operation a segment of wall sealing material may be inserted by ceasing to pump from the regular suction pit and transferring the suction to one of the separate tanks connected to the intake side of the pump. According to a preferred method of operation, in one of these tanks there is a saturated brine which is pumped in a volume that would make up perhaps a 50 ft. slug segment as it flows upwardly from the hole. After this segment of saturated brine has been introduced, a segment of cellulose solution is introduced into the circulation system from the other tank. This in turn may be followed by another segment of saturated brine from the first auxiliary tank. Thereafter the suction is again connected with the suction pit and the drilling operation continued with the regular drilling fluid. The brine introduced into the system before and after the cellulose solution acts as a buffer and prevents any reaction between the regular drilling fluid and the cellulose solution tending to prevent precipitation of the rubber-like cellulose hydrate in the drill bit. It is not absolutely essential, however, to employ this buffer solution because there is comparatively little mingling of the cellulose solution and the regular drilling fluid when the cellulose solution is introduced into the system in the form of a slug or segment as above described. The desirability of using a buffer solution also depends somewhat upon the exact nature of the regular drilling fluid.

The invention will be further illustrated but is not limited by the following example:

Example

A well is drilled with an oil well drilling fluid consisting of about 24% calcium chloride, about 41% zinc chloride, a small amount of a zeolitic clay such as described in U. S. Patent 2,044,758, and the balance water. For the purpose of forming a rubber-like seal in the hole, two separate auxiliary tanks are connected with the pump intake. When the drilling operation is started, the regular drilling fluid described above is pumped from the regular suction pit. At intervals thereafter the operation of pumping from the regular suction pit is stopped and suction is transferred to one of the auxiliary tanks containing a saturated zinc chloride brine. This saturated brine is pumped in a volume which makes up about a 50 ft. slug or segment as it flows upwardly through the hole. Immediately following this slug of saturated zinc chloride, another slug of a solution of cellulose in substantially saturated zinc chloride is introduced into the system from the second auxiliary tank, this second segment likewise making up about a 50 ft. segment as it flows upwardly through the hole. After this segment or slug of cellulose zinc chloride has been introduced into the system, another segment of plain saturated zinc chloride solution is introduced from the first auxiliary tank, and this in turn is followed by switching the system back onto the regular drilling fluid.

The operation may be accomplished by any suitable arrangement of valved conduits operated either manually or automatically.

The solution of cellulose in zinc chloride may be prepared by steeping about 5% of a cellulose material with a zinc chloride solution containing 50% water and 50% zinc chloride at a temperature of about 200° F. until the mixture is of a mucous-like consistency. The source of cellulose may be cotton, cotton linters, straw, sawdust, cotton seed hulls, rags, wood pulp, rice hulls or other sources of cellulose. It is ordinarily preferable to use as clean a source of cellulose as possible. The concentration of zinc chloride may be higher or somewhat less, but preferably in excess of 40% by weight. Thus, a solution of zinc chloride in water of the character described will dissolve, at the temperature of boiling water, up to 10% of cellulose to produce a high viscous gelatinous mixture, and if desired, the percentage of zinc chloride may be as high as 82%. Zinc chloride solutions are in themselves very heavy, and in zinc chloride solutions of cellulose it is possible to attain not only weight but viscosity, the specific gravity of the mixture preferably varying between about 1.30 and 2.25, and the viscosity within the range of about 1 to 100 centipoises, preferably about 5 to 50 centipoises.

The viscosity of the zinc chloride solution of cellulose introduced into the drill hole in the form of a segment, as above described, is such that a substantial coating is formed on the wall of the drill hole. The saturated solution of zinc chloride which immediately follows the zinc chloride solution of cellulose in the method of operation previously described has no substantial effect upon the coating formed on the wall, but the more dilute solution of regular oil well drilling fluid which is thereafter introduced into the drill hole acts upon the zinc chloride solution of cellulose deposited on the walls of the hole to form a rubber-like seal. Such a seal is not possible with the regular type of drilling fluid alone.

It might be supposed that mixing would take place between the cellulose solution and the segments adjacent thereto, but no substantial mixing does occur. As previously indicated, while the use of buffer solutions is preferred, in some instances, the operation may be carried out by eliminating the buffer solution between the drilling mud and the cellulose solution, the intermingling of the cellulose solution and the drilling mud at the boundaries of the segments not being sufficient to prevent successful operation.

In its broader aspects the invention is appli-

cable to the insertion into the drilling system of a segment or slug of material differing in its characteristics from the regular drilling fluid and having a predetermined action with the drilling fluid. Other inert or buffer materials may be used between the segments. Other types of brine fluids may be used in the regular drilling fluid, as, for example, brines made from sodium chloride, calcium chloride, ferrous sulfate, ferric sulfate and various mixtures thereof. Zinc chloride brines of other concentrations may be used and zinc chloride may be included in brines made from one or more of the aforementioned salts. Fresh water drilling muds may be employed. Any other type of cellulose solution may be used which will react with the regular drilling fluid selected.

It will be apparent that by the method of operation herein described, materials can be used which would ordinarily be far too expensive to be considered as oil well materials composing an entire circulatory system. A zinc chloride solution of cellulose is particularly advantageous because such solutions may readily be prepared having a weight approximating that of the regular drilling fluid. Hence, there is no danger of the back-pressure blowing the segment out of the drill hole. The same is also true with respect to buffer solutions consisting of saturated zinc chloride solutions. Inasmuch as the various segments of materials all have the necessary weight, their introduction does not affect the drilling operation which may be carried on continuously and without interruption.

Many reactions, chemical or physical, may be taken advantage of with this method of operation and organic sealing agents, which are too expensive according to the present art, may be used. For example, a jell may be made with a lignin compound in the acid condition which liquefies in the alkaline condition. As a further example, in inorganic reactions, a sodium phosphate slug may be used in connection with a zinc chloride brine to form a hard precipitate. It is thus obvious that this invention provides a method of drilling having a much wider range of possibilities for the development of wall sealing in the drill hole.

Having thus described the invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. In the art of drilling oil and gas wells, the steps which comprise carrying out the drilling operation with a brine drilling fluid capable of precipitating cellulose or cellulose hydrate from a zinc chloride solution of cellulose, and introducing into the drilling system at intervals during the general course of the drilling operation segments of a zinc chloride solution of cellulose, each segment being separated from the regular drilling fluid in the system by a buffer material which is substantially non-reactive with both the regular drilling fluid and the cellulose solution.

2. In the art of drilling oil and gas wells, the steps which comprise carrying out the drilling operation with a brine drilling fluid capable of precipitating cellulose or cellulose hydrate from a zinc chloride solution of cellulose, and introducing into the drilling system at intervals during the general course of the drilling operation segments of a zinc chloride solution of cellulose, each segment being separated from the regular drilling fluid by a substantially saturated solution of zinc chloride.

3. In the art of drilling oil and gas wells, the step which comprises introducing into the drilling system at intervals during the general course of drilling a segment of a precipitatable wall sealing material differing in its characteristics from the regular drilling fluid and subject to precipitation by contact with the regular drilling fluid, said precipitatable material comprising a cellulosic substance in soluble form and being separated from the regular drilling fluid during circulation by a buffer segment of material which is non-reactive with the precipitatable material and with the regular drilling fluid.

4. In the art of drilling oil and gas wells, the step which comprises circulating in the drill hole during the general drilling operation liquid containing cellulose in soluble form and adapted to be regenerated and a regenerating material for said cellulose separated from said cellulosic liquid by a non-reactive buffer material.

5. In the art of drilling oil and gas wells, the step which comprises successively circulating in the drill hole during the general course of drilling the well a substantial quantity of zinc chloride solution in which cellulose is dissolved or suspended in colloidal condition, a concentrated zinc chloride buffer solution sufficiently concentrated to prevent precipitation of the cellulose and a zinc chloride solution of less concentration adapted to precipitate cellulose as a wall sealing agent on the sides of the drill hole.

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