BACK-PRESSURE CONTROL IN PRESSURE DRILLING

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This invention relates to a system of handling drilling fluids in connection with pressure drilling operations. More particularly it relates to a method and apparatus for controlling back pressure in such operations.

In drilling wells, particularly oil and gas wells, it has long been customary to use a drilling fluid, usually a so-called drilling mud, to carry away the cuttings, cool and lubricate the bit, build walls and prevent the intrusion of unwanted fluids into the well. More recently drilling operations have been carried out in which the drilling fluid is under a pressure in excess of that corresponding to the hydrostatic pressure of the fluid column.

Such pressure drilling operations are particularly important in areas where heaving shale is encountered, especially in areas where the pressures encountered in a bore hole shift from that determined by the hydrostatic head to that controlled by the overburden or overlying earth pressure. It is my belief that this shifting of pressures is sometimes quite abrupt, especially in Gulf Coast areas, in which case the pressure within less than 100 feet can change from one based on approximately 470 pounds per 1000 feet in depth to one more than double that figure.

However this may be, pressure drilling operations are very useful to obtain a bottom hole mud pressure sufficiently high to mud off a caverning or heaving formation without resorting to the use of excessive amounts of weighting materials; to keep oil, water or gas from coming into the hole; to bring in a well without sealing off production with heavy drilling fluids; and to drill or bring in a well with a controlled flow, thus preventing initial velocities in a producing formation which might break down the walls of the well and cause excessive caving or heaving.

The conventional method of circulating mud, oil or other drilling fluid is down through the drill pipe and up through the annular space between the drill pipe and the casing although reverse circulation is commonly used in connection with pressure drilling operations. The drilling fluid discharged from the top of the well can be handled in a closed system without releasing its pressure by having an automatically controlled circulation pump floating on the mud in the well. The circulation pump maintains the mud pressure in the well.

It has therefore been considered necessary in many pressure drilling operations to maintain the back pressure on the drilling fluid by the use of reducing valves or chokes through which the circulating fluid is vented to atmospheric pressure. The mud then flows into the conventional settling pits or is otherwise handled at atmospheric or other relatively low pressure to remove cuttings and then picked up at this low pressure by the circulating mud pumps and reinjected into the well. However, in using this system under Gulf Coast conditions I have found that even by using both vibrating screens and centrifuges for the elimination of cuttings, these cuttings cannot be eliminated satisfactorily. Apparently the mud passing through a choke across which its pressure is reduced from, for instance, 1,000 pounds per square inch to atmospheric, is subjected to a very severe shearing action which converts the shales or clays into a finely divided or colloidal state. This raises the viscosity of the mud so high that it cannot be handled efficiently and at the same time greatly lowers its "weight" or density which is often artificially obtained by the use of expensive weighting materials. This loss of weight is due to the failure to remove the shale cuttings from the mud and since these cuttings are of lower density than the average density of the mud there is a continual reduction in mud weight.

For these reasons I have found it essential either when the back pressure is controlled by an enclosed circulation system with pressure separation of cuttings or when the back pressure is controlled by the use of chokes, to control the weight and viscosity of the drilling mud by continuously adding water to reduce viscosity and added weighting materials to increase the specific gravity. Not only is this highly expensive but I have found it practically impossible. Thus in a specific case, under Gulf Coast conditions, it was found that the weight of the mud could not be increased appreciably beyond 10 pounds per gallon and with the back pressure limited to 1,000 pounds per square inch it was calculated that a 12 1/2 pound mud was required to hold back the heaving shale. Not being able to obtain a mud weight above 10 pounds the heaving shale finally closed in on the drill pipe, sticking it and losing the hole.

The colloidal clay and shale troubles encountered in pressure drilling operations in certain Gulf Coast and other areas is not due to the high mud pressures used but rather to the shearing action which takes place when the pressure is...
suddenly reduced across a choke. In other words, when the pressure is continuously and gradually reduced through the normal flow of the mud from about 1000 pounds per square inch to atmospheric no trouble is encountered in removing the cuttings.

It is an object of my invention to provide new and improved methods of back pressure control in pressure drilling operations. Another object of my invention is to provide apparatus for this purpose. A more detailed object of my invention is to provide methods for the more complete removal of cuttings from drilling fluids used in pressure drilling operations. A further object of my invention is to provide drilling fluid handling systems in which the cuttings can be removed more completely and satisfactorily than has heretofore been the case and in which this is done without substantial loss of the energy available by virtue of the pressure of the drilling fluid coming from a pressure drilling operation.

My invention will be described with particular reference to the accompanying drawing which is simplified diagrammatically, partly in section, of one form of apparatus in which my invention can be carried out.

In brief my invention contemplates the use of an hydraulic motor as a back pressure regulator. The high pressure drilling fluid is used to operate such a motor and in the course of this operation its pressure is reduced without subjecting any appreciable part of the drilling fluid to any shearing action since it enters the cylinder or motor chamber at high pressure and leaves at low pressure without any sudden pressure drop across an orifice as occurs when the pressure is reduced across a valve or choke.

Turning more particularly to the drawing, the well being drilled is not shown in its entirety but only the parts which are important from the standpoint of the present invention. Casing is equipped with master control gate valve and packer or blow-out preventer through which the drill pipe carrying rock bit is inserted. The packer can, of course, be of any desired type, for instance the Hydril type, although a simple form is shown. Above this packer is the conventional equipment, including the rotary table, the kelly drive and associated devices, but these have been omitted from the drawing. Above them the upper end of the kelly (or the drill pipe itself if no kelly is used) is connected to swivel through which drilling mud under high pressure is introduced from the discharge of mud pump by means of line and flexible hose.

Drilling mud thus introduced may be at a pressure which will depend upon many factors familiar to those skilled in the art. Generally speaking, the pressure at which the drilling fluid is introduced will range from about 1500 to about 5000 pounds per square inch, typically about 3000 pounds per square inch. This drilling fluid passes down through the drill pipe to the base of the well and then up through the annular space between the drill pipe and the casing. However, my invention is equally applicable to a system in which the circulation is maintained in the other direction, i.e., so-called reverse circulation. The drilling fluid at a back pressure of from about 500 to about 2000 pounds per square inch, for instance about 1500 pounds per square inch, passes from the annular space between tubing and casing out through line which is preferably entirely free of chokes and other obstructions across any substantial pressure drop would occur and hence to a pressure reducer which can be described as a pump with two fluid ends and running in reverse, i.e., as an hydraulic motor, the mud entering the cylinder at high pressure and doing work on the piston through out the working stroke, at the end of which the cylinder is closed by a mechanical valve and pressure admitted to the opposite side of the piston, the mud which has already done its work being expelled to the atmosphere.

Thus in pump the pressure is reduced, preferably, from 1000 pounds per square inch to atmospheric or other low pressure and the drilling mud passes to the mud tank, pit or other mud settling chamber in which the cuttings settle out. It is, of course, possible to place a vibrating screen or other cutting separator between pump and mud pit if desired.

Power made available by the expansion of the drilling mud in the motor chamber is then utilized in various ways. Thus for instance, fluid end of pump can be used to pick up mud from the mud tank or pit and then passed to the motor through line and entire pump is then operated in reverse. Thus, this fluid end of pump operated by the high pressure drilling mud in motor can be made of small size relative to end and can be utilized to boost the pressure on a small part of the drilling mud to the pressure at which it is introduced through line and hose. This can be accomplished by opening valves and closing valves and. Thus the energy made available by the expansion of the drilling mud is used to pump a quantity of drilling mud to the higher pressure used for injection and fluid end then operates in parallel with the other end.

A still further method of using this energy is to close valves and open valves and thus using the fluid end of pump in series with the main mud pump, powered by steam or other external power, to handle the total amount of mud reinjected into the well.

The system of my invention need not be confined to the use of a reciprocating type motor to reduce the drilling fluid pressure, as either single or multiple stage rotary gear or displacement pumps or other prime movers might be substituted as hydraulic motors, the main object being to release the pressure of the drilling fluid without the use of a shearing choke, since pressure release is necessary to remove the drill cuttings efficiently.

While I have described my invention in connection with certain specific embodiments thereof, it is to be understood that these are by way of illustration and not by way of limitation and I do not mean to be bound thereby but only to the scope of the appended claims which should be construed as broadly as the prior art will permit.

1. In a pressure drilling operation in which drilling fluid comes from a well at a high pressure carrying cuttings, the steps which comprise reducing the pressure on said drilling fluid to an 75
proximately atmospheric pressure without subjecting it to any substantial shearing action, removing cuttings from the drilling fluid at approximately atmospheric pressure, and reinjecting said drilling fluid, after removal of said cuttings, into said well at a high pressure.

2. In a pressure drilling operation in which drilling fluid comes from a well at a high pressure carrying cuttings, the steps which comprise reducing the pressure on said drilling fluid by causing it to operate an hydraulic motor, removing cuttings from the drilling fluid at approximately atmospheric pressure, and reinjecting said drilling fluid, after removal of said cuttings, into said well at a high pressure.

3. In a pressure drilling operation in which drilling fluid comes from a well at a high pressure carrying cuttings, the steps which comprise reducing the pressure on said drilling fluid by causing it to do mechanical work, removing cuttings from the drilling fluid at approximately atmospheric pressure, reinjecting said drilling fluid, after removal of said cuttings, into said well at a high pressure, and using said mechanical work to operate an auxiliary mud pump.

4. In pressure drilling apparatus comprising a line for drilling fluid under pressure leading from a well, a drilling fluid settling chamber and means for reinjecting said drilling fluid from said settling chamber into said well, the improvement which comprises a prime mover arranged to be operated by the drilling fluid under pressure flowing through said line and adapted to discharge said drilling fluid into said settling chamber at greatly reduced pressure without subjecting it to any substantial shearing action.

5. In pressure drilling apparatus comprising a line for drilling fluid under pressure leading from a well, a drilling fluid settling chamber and means for reinjecting said drilling fluid from said settling chamber into said well, the improvement which comprises a prime mover arranged to be operated by the drilling fluid under pressure flowing through said line and adapted to discharge said drilling fluid into said settling chamber at greatly reduced pressure without subjecting it to any substantial shearing action, and an auxiliary drilling fluid pump operated by said prime mover and arranged to recirculate drilling fluid from and to said settling chamber.

6. In a pressure drilling apparatus comprising a line for drilling fluid under pressure leading from a well, a drilling fluid settling chamber and means for reinjecting said drilling fluid from said settling chamber into said well, the improvement which comprises a prime mover arranged to be operated by the drilling fluid under pressure flowing through said line and adapted to discharge said drilling fluid into said settling chamber at greatly reduced pressure without subjecting it to any substantial shearing action, and an auxiliary drilling fluid pump operated by said prime mover and arranged to assist said means for reinjecting said drilling fluid from said settling chamber into said well.

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