

DRILL PIPE**TECHNICAL FIELD OF THE INVENTION**

This invention relates to drilling, and in particular to drilling using a drilling fluid conveyed through drill pipe.

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CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of pending U.S. Application Serial No. 07/918,049 filed July 24, 1992.

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SUBSTITUTE SHEET (RULE 26)

BACKGROUND OF THE INVENTION

In drilling, a drill bit is typically rotated and moved forward in the borehole by a drill string made up of a number of individual drill pipes. Often, the drilling action of the bit is assisted by the flow of a drilling fluid or mud flowing through the drill pipe. The fluid is discharged at the drill bit to cool the bit and remove debris. The drilling fluid then flows out of the borehole in the annulus formed between the drill string and the wall of the borehole.

In horizontal drilling of the type used in trenchless drilling technology, fluid is typically discharged at the drill bit through a nozzle jet or jets to increase discharge velocity. Corrosion particles in the fluid tend to plug filter screens and nozzles, and reduce or block fluid flow. High quality steel drill pipe is typically coated on its inside surface to minimize the amount of corrosion and particle generation as the drilling fluid flows through the pipe. Such a coating process is expensive. The extra coating requirement adds direct manufacturing costs, handling costs, inventory costs, environmental costs and quality costs to the finished product. To date, filling the entire interior volume of the drill pipe and conveying the drilling fluid in direct contact with the drill pipe interior wall has been the only mechanism to deliver the drilling fluid to the drill bit at the cutting face. However, a need exists to improve this delivery system and reduce the total costs of the drilling operation, including the costs of drill pipe manufacturing.



SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, a drill pipe is provided for use in a drill string rotating a drill bit and conveying a drilling fluid. The drill pipe includes a pipe section having a first end and a second end. A pin end having a male threaded portion and a passage formed therethrough is welded or by some other means formed onto or attached to the first end of pipe section. A box end having a female threaded portion and a passage formed therethrough is welded or by some other means formed onto or attached to the second end of the pipe section. A metal, plastic, or composite construction tube or hose is inserted into the interior of the pipe section and extends between the pin end and the box end to convey drilling fluid through the drill pipe. The volume of the tube or hose reduces the interior volume of the pipe section to decrease fluid use and time required to reach operating pressure.



BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cross-sectional view of a drill pipe of welded construction forming a first embodiment of the present invention;

FIGURE 2 is a cross-sectional view of a box end used in a drill pipe of welded construction;

FIGURE 3 is a cross-sectional view of a pin end used in a drill pipe of welded construction;

FIGURE 4 illustrates a second embodiment of the invention with a drill pipe of arc welded construction with an internal conduit that is a rigid or flexible tube;

FIGURE 5 illustrates a modification of the second embodiment of the invention with a drill pipe with an internal conduit, with the drill pipe of spin, inertia, or friction weld construction;

FIGURE 6 illustrates another modification of the second embodiment of the invention with a drill pipe with an internal conduit that is a rigid or flexible tube and the drill pipe shows one type of forged upset end construction;

FIGURE 7A is a cross-sectional view of a drill pipe of welded construction forming a third embodiment of the present invention;

FIGURE 7B is a detail view of a hose fitting used in the third embodiment;

FIGURE 8 is a cross-sectional view of a box end used in the drill pipe of welded construction of FIGURE 7A;

FIGURE 9 is a cross-sectional view of a pin end used in the drill pipe of welded construction of FIGURE 7A;



FIGURE 10 illustrates a fourth embodiment of the invention with a drill pipe of arc welded construction with an internal conduit that is a rigid or flexible tube;

FIGURE 11 illustrates a modification of the fourth embodiment of the invention having a drill pipe with an internal conduit with arc welded ends having no extension;

FIGURE 12 illustrates a modification of the fourth embodiment of the invention having a drill pipe with an internal conduit, with the drill pipe of spin, inertia, or friction weld construction;

FIGURE 13 illustrates another modification of the fourth embodiment of the invention with an internal conduit that is a rigid or flexible tube and the drill pipe shows one type of forged upset end construction;

FIGURE 14 illustrates a fifth embodiment of the invention with a drill pipe of arc welded construction with an internal conduit that is a rigid or flexible tube which incorporates pipe nipples and insulator bushings;

FIGURE 15 is a view of the rigid or flexible tube;

FIGURE 16 is a view of the insulator bushing; and

FIGURE 17 is a view of the pipe nipple.



DETAILED DESCRIPTION

With reference now to the accompanying figures in the following Detailed Description, a drill pipe 10 forming a first embodiment of the present invention is described.

5 As can be seen, the drill pipe is formed of a number of elements, including a cylindrical pipe section 12. At a first end of the pipe section is welded a box end 14. At the other end of the pipe section is welded a pin end 16. A hydraulic hose assembly 18 is secured between the
10 ends 14 and 16 and runs within the interior of the pipe section 12. The ends 14 and 16, and pipe section 12, are designed to transmit the forces, including torque, necessary for the drill bit to perform its function. The drilling fluid is conveyed between the ends 14 and 16
15 within the drill pipe through the hydraulic hose assembly 18.

The design of drill pipe 10 has significant advantages. The pipe section 12, and ends 14 and 16 can be designed to optimize the force carrying characteristics
20 required for the drill bit. A one-piece rotating drill pipe of stiff construction and thin wall is advantageous for economical manufacturing cost. Because the interior surface 20 of the pipe section 12 will not be exposed to drilling fluids, no expensive protective coating need be
25 applied to this interior surface. In prior designs, a coated surface was a requirement to protect the interior wall of the drill pipe from corrosion and to prevent debris, such as rust particles, from traveling in the drilling fluid and plugging up the nozzle openings of the
30 drill bit. This is particularly critical when using low pressure, low flow rate nozzle openings. The pipe section 12 can therefore be designed solely on the basis of torque and force requirements of the drilling unit, and not as a pipeline to convey the drilling fluid.



In addition, the size of the hydraulic hose assembly 18 can be selected to optimize the flow characteristics of the drilling fluid being utilized. In the past, when the drilling fluid simply flowed through the interior volume 22 of the drill pipe, sufficient drilling fluid would have to be pumped into the drill string to fill up each drill pipe before the drilling fluid could be delivered at the drill bit with sufficient flow and pressure. Every time the drilling operation was halted, a portion of this drilling fluid would flow out of the drill string. To initiate further drilling, the lost drilling fluid would have to be replenished in the drill string before the drilling fluid would again be delivered to the drill bit with sufficient pressure and quantity. This procedure contributes to wastage of large volumes of drilling fluids, and drilling operation time delays. In addition to the high cost of drilling fluids, the fluids are becoming an ever greater environmental concern and the elimination of waste of the drilling fluid is an increasingly significant advantage.

With reference to FIGURES 1-3, further details of the drill pipe 10 will be described. As can be seen, the box end 14 has a reduced diameter portion 24 which has an outer surface 26 designed for a close fit with the interior surface 20 of the pipe section 12. A stepped portion 28 forms a transition between outer surface 26 and the exterior portion 30 of the box end. The portion 28 reduces stress concentration and also provides a groove for the weld bead 32 which secures the box end to the pipe section. The outer diameter of the exterior portion 30 is larger or preferably equal to the outer diameter of the pipe section 12.

Female connection thread 36 is formed in the interior portion 30 to receive the pin end of the adjacent drill



pipe, allowing the drill pipes to be threaded together. A female pipe thread 38 is formed in the reduced diameter portion 24 and a passage 40 is formed through the box end.

5 The pin end has a reduced diameter portion 42 which is a tight fit with the interior surface 20 of the pipe section 12. A stepped portion 44 forms a transition between the outer surface 46 of the reduced diameter portion 42 and the exterior portion 48 of the pin end. Again, the portion 44 defines a groove for weld bead 50 to
10 weld the pin into the pipe section 12. A male connection thread 52 is formed on the exterior portion 48 to thread the drill pipe to the box end of the adjacent drill pipe. A female pipe thread 54 is formed into the reduced diameter portion 42 and a passage 56 extends through the
15 pin end.

With reference to FIGURE 1, the hydraulic hose assembly 18 can be seen to include a male threaded connector 58, a flexible hose 60 and a male threaded connector 62. The male threaded connector 58 is
20 threadedly received in the female pipe threads 38 of the box end. The male threaded connector 62 is threadedly received in the female pipe threads 54 of the pin end 16.

If desired, the common hydraulic hose assembly 18 could be replaced by a rigid or flexible tube or hose 90
25 with ends sealed to the passage through the box and pin ends as shown in FIGURE 4. For example, the rigid or flexible tube 90 could have threaded ends to be received in threads 38 and 54. Alternatively, O-ring seals or any other combination of threads, seals, press fits, O-rings,
30 or adhesive joint could be used to join the rigid or flexible tube to the box and pin ends. A press fit joint 92 is shown in FIGURE 4. The internal tube 90 could be made of a variety of materials, including stainless steel, some other metal, plastic or composite construction.



5 The hydraulic hose assembly 18 can be installed in the pipe section 12 and attached to the pin and box ends before inserting the ends 24 and 42 into the pipe section 12 to be welded. It would be possible to have sufficient extra length in the hose 60 to allow the ends to be made up by hand prior to welding the pin and box end in place in the pipe section. Alternatively, as the hose has flexibility, a mechanism could be utilized to stretch the hose sufficiently to tighten the hose assembly to the box and pin ends using little or no excess hose within the pipe section.

10 The rigid or flexible tubing or hose would be installed in a manner similar to that used in the common hydraulic hose installation. Alternatively, the tubing could be installed after the drill pipe elements are assembled or formed together. This could allow friction welded construction of the drill pipe and replacement repair of the tube. FIGURE 5 illustrates a drill pipe 100 having box end 102 and pin end 104 friction welded at welds 108 onto the pipe section 106. The tube 90 is sealed at its ends to the box end 102 and pin end 104.

15 Also, this could allow the tubing to be installed in a drill pipe 120 of forged upset ends 122 and 124 as seen in FIGURE 6, and/or machined, and/or threaded joint end or ends construction. This "non-welded" construction of the drill pipe is required for some drilling applications. This method of design would also allow replacement repair of the tube.

20 In accordance with drill pipe assembled using the teachings of the present invention, the drill pipe in service was judged roughly equivalent to current fusion bonded epoxy coated drill pipe in corrosion resistance but at significantly less cost and higher more uniform quality. The drilling fluid volume contained inside the



drill pipe was decreased approximately 86% from drill pipe without a hose assembly, leading to a significant reduction in wasted drill fluid especially when removing drill pipe during a backreaming operation. The response time required to bring the drill pipe to the appropriate fluid pressure for drilling and backreaming was also greatly reduced by the reduction of fluid volume inside the drill string.

FIGURES 7-9 illustrate a third embodiment of the present invention forming a drill pipe 200. A number of elements of drill pipe 200 are identical to that of drill pipe 10 and are identified by the same reference numerals. However, the hydraulic hose 202 utilized in drill pipe 200 has an outer diameter which is just slightly less than the inner diameter of the inner surface 20 of the pipe section 12. Also, inserted into each end of the hose is the reduced end portion 203 of a hose end fitting 204 as seen in FIGURE 7B. The hose end fittings 204 contact the box end 14 and pin end 16 but are not attached or sealed thereto. A flow path is formed through passage 40, the passages 205 formed through hose fittings 204, the hose 202, and passage 56.

As noted, the hose fittings 204 are not sealed to or attached to the box end 14 and pin end 16. Thus, fluid is permitted to escape or leak between the abutting ends of the hose fittings and the ends 14 and 16 and into the annulus formed between the outer surface of the hose 202 and the inner surface 20 of the pipe section 12. During use, rust may form on the inner surface 20, but it is mostly trapped between the outer surface of the hydraulic hose 202 and the inner surface 20 and large quantities of rust particles will not therefore enter the main fluid stream passing through the interior of the hydraulic hose 202. The advantages of the present invention are



therefore maintained as the interior volume of the drill pipe 200 is reduced by the volume of the hydraulic hose 202 and the hose fittings 204 and the rust problem is controlled. The difference in diameter between the outer surface of the hose and the inner surface of the pipe section was only .01675" in one drill pipe made in accordance with the teachings of the present invention.

The hose 202 can be sealed to the reduced diameter portions of the hose fittings 204 or not as desired. The use of hose fittings 204 is primarily to act as mechanical protection for the ends of the hydraulic hose 202, which otherwise would be exposed to the high pressure fluid flow traveling through the ends 14 and 16. Without such protection, this high velocity flow would likely tear, render or otherwise distort the hose which, in the worst case, could block the passage through the drill pipe.

The drill pipe 200 thus has a number of advantages over the previous embodiments described. Namely, as there is no concern to have sealed connections between the tube or hydraulic hose and the ends of the pipe, the cost of such fittings are eliminated. Further, the drill pipe can be made up quicker and with less effort because sealed connections are not used. With this design, as shown in FIGURES 8 and 9, the female pipe thread 38 of box end 14 and female pipe thread 54 of pin end 16 are eliminated. Also, the unsealed tube or hose does not bear the stresses involved when a sealed tube holds a high internal pressure against a much lower external pressure. Thus, the conduit construction can be simpler and less expensive.

With reference to FIGURE 10, the drill pipe 210 can be seen to use a rigid or flexible tube 212, preferably of PVC plastic, which has an outer diameter very slightly less than the inner diameter of the pipe section 12 of the drill pipe 210. Again, the ends 214 of the tube or hose



212 can bear against the inner ends of the box end 14 and pin end 16 to form a continuation of the passage through the ends but without being sealed to the ends. Therefore, the fluid can again pass to the annulus between the outer diameter of the tube 212 and the inner surface 20 of the pipe section 12. However, again whatever rust generation occurs will be to a large extent trapped within that annulus.

The ends of the tube 212 are preferably drilled to form recesses 215 to receive the extension 216 of ends 14 and 16, with a clearance of preferably 0.04 inches between the outer surface of the extensions 216 of the ends 14 and 16 and the inner surface of recesses 215 in the tube 212.

With reference now to FIGURE 11, a drill pipe 210 can be seen to be formed having box end 14 and pin end 16 arc welded at welds onto the pipe section. The box end 14 and pin end 16 do not have extensions as described in the embodiments of FIGURES 7-10. The end of the tube 212 simply bears against the inner end of the box end 14 and pin end 16. Again, fluid can leak between the box end, pin end and tube 212 into the annulus between the outer surface of the tube 212 and the inner surface 20 of the pipe section.

With reference to FIGURE 12, the drill pipe 210 can be seen to be formed having box end 102 and pin end 104 friction welded at welds 108 onto the pipe section 106. The tube 212 is again not sealed at its ends to the box end 102 and pin end 104. A flush trim is preferably done on the weld flash from the weld between the box end inside diameter 102 and the pipe section 12 to allow the tube 212 to be inserted into the interior volume of the drill pipe through the box end after the ends have been welded on the pipe section.



With reference to FIGURE 13, drill pipe 220 can be formed with forged upset ends 122 and 124 and/or machine, and/or threaded joint end or ends construction. The tube 212 would fit within the drill pipe 220 and bear against the forged upset end 124 to form a continuous passage through the drill pipe without being sealed to the upset ends. The tube is inserted into the drill pipe through the box upset end 122.

With reference now to FIGURES 14-17, a fifth embodiment of the invention is illustrated and is formed by drill pipe 250. Again, the drill pipe 250 is formed of a pipe section 12 with a box end 14 arc welded at one end of the pipe section 12 and a pin end 16 arc welded at the other end of the pipe section 12. Each of the ends 14 and 16 have a threaded aperture 252 formed at their inner ends which face the interior of the drill pipe.

Two pipe nipples 254 are provided which each have threaded ends 256. One threaded end of each of the pipe nipples 254 is threadedly engaged with the threaded aperture 252 in each of the ends 14 and 16. Thus, the pipe nipples 254 effectively form extensions of the box end and pin end into the interior of the pipe section.

An insulator bushing 258 is received over each of the pipe nipples 254 as shown in FIGURE 14. The inner diameter of the insulator bushing 258 is sufficiently larger than the outer diameter of the pipe nipple 254 to allow an easy slip fit over the nipple. There is no desire for a tight or sealed fit between the insulator bushing and the pipe nipple. The outer diameter of the insulating bushing is somewhat less than the inner diameter of the inner surface 20 of the pipe section 12.

Rigid or flexible tube 260 is placed within the interior of the pipe section 12 with a portion of each of the pipe nipples 254 extending into the ends of the rigid

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or flexible tube 260. As best seen in FIGURE 15, the rigid or flexible tube has a bore 262 formed through its entire length to form a continuation of the passage through the drill pipe and a larger diameter recess 264 in each end of the tube to receive the ends of the pipe nipples 254. The rigid or flexible tube is preferably formed of PVC plastic. However, other materials are suitable including other plastics, various metals or composites. Of the metals, aluminum would be particularly suitable. In the composites, a composite wound tubing or plastic filament wound tubing or hydraulic hose would be suitable.

In one drill pipe constructed in accordance with the teachings of the present invention, the rigid tube 260 was formed of PVC having an outer diameter of about 1.165 inches and a bore of about .51 inch. The diameter of the recess was .719 inch and the recess was about 2.2 inches deep. The insulator bushing had an outer diameter of 1.165 inches and an inner diameter of about .719 inch. The bushing was about one inch long and was formed of well seasoned, select grade, yard lumber such as white birch, silver maple or big leaf maple.

The nipple was formed of Schedule 40 pipe steel having three-eighths inch national pipe threads cut at each end. The nipple was about three and one-half inches long. The outer diameter of the nipple was .675 inch and the inner diameter was .493 inch forming a wall thickness of .091 inch. The gap between the outer surface of the rigid tube and insulator bushings 258 and the inner surface 20 is in the range of 0.013 inch to 0.028 inch.

The function of the insulator bushings 258 is to prevent damage to the PVC tube 260 as the ends 14 and 16 are being arc welded to the pipe section 12. In designs with friction welding and upset forming, the tube simply



slips in the box end of the drill pipe after the pipe has been manufactured. Once the drill pipe has been used in service, the build up of fluids, grit and rust will usually cause the tubes to stay within the drill pipe unless effort is undertaken to remove them. Field replacement of worn or otherwise damaged liner tubes would be possible.

Although several embodiments of the invention have been illustrated and described with numerous specific details in the foregoing description and accompanying drawings, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions of parts and elements without departing from the spirit and scope of the invention.





CLAIMS:

1. A drill pipe for use in a drill string rotating a drill bit or backreaming tool and conveying a drilling fluid, comprising:

a pipe section having a first end and a second end:

a pin end having a male fitted portion and a passage formed therethrough, the pin end secured to the first end of the pipe section;

a box end having a female threaded portion and a passage formed therethrough, the box end secured to the second end of the pipe section; and

a drilling fluid conveying device positioned between the pin end and the box end to convey drilling fluid through the pipe section interior but not sealed to the pin end or box end.

2. The drill pipe of Claim 1 wherein the drilling fluid conveying device includes a hose having a first end and a second end, a first hose fitting fit within the first end of the hose and a second hose fitting fit within the second end of the hose.

3. The drill pipe of Claim 1 wherein the drilling fluid conveying device is a tube.

4. The drill pipe of Claim 3 wherein the tube is made of PVC plastic.

5. The drill pipe of Claim 1 wherein the pin end and box end are arc welded to the pipe section.

6. The drill pipe of Claim 1 wherein the pin end and box end are upset forged from the pipe section.

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7. The drill pipe of Claim 1 wherein the pin end and the box end are friction welded to the pipe section.

8. The drill pipe of Claim 1 wherein the pin and/or box ends are fixed or formed onto the pipe section by any combination of or design of interference fit, threaded, forged, or welded joint.

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