NOZZLE RETENTION DEVICE FOR ROCK BITS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to replaceable nozzles for rock bits utilizing drilling fluid to remove detritus from an earthen formation borehole.

More particularly, this invention relates to a retention device utilized to secure replaceable nozzles in rock bit bodies. The device provides a means to both minimize fluid erosion and assure a more uniform flow of drilling fluid contained within a plenum formed by the rock bit body to the nozzles.

2. Background

Replacement nozzles require a means of being retained into rock bits. The more typical retention methods for securing nozzles are mechanical and are machined either directly into the bit body or into a sleeve that is in turn welded into bores formed in the rock bit body.

Weld-in nozzle sleeves have been used in rotary cone rock bits for several years for ease of manufacturing. An internal plenum interfaces with secured nozzles via a relatively narrow passage bore formed adjacent to the plenum, of which a portion of the passage way is included in the welded-in sleeve, if a sleeve is utilized.

Internal erosion, in and around nozzle bodies is a major problem. A loss of hydraulic pressure downhole results in a trip out of the borehole and often times the bit is replaced due to the extent of damage to the bit as a result of fluid erosion.

Internal erosion in a rock bit can typically be related to four parameters, mud weight, mud abrasiveness, flow velocity and geometrical discontinuities i.e. gaps, bend, corners and the like. The current nozzle retention configurations are limited in flow capacity by creating a high fluid velocity over a sharp corner formed in the bit adjacent the passage bore entrance. High flow rates cause the fluid flow to separate at the corner creating

recirculation zones with sufficient energy to erode the surrounding metal surface that, as heretofore stated, has caused bit washout.

Another potential problem with the state of the art weld-in sleeve is gaps formed between the sleeve and the leg or bit body interface. Gaps may occur at this interface if correct manufacturing procedures are not followed. High fluid flow over gaps where the depth of the gap is much greater than the width will tend to cause recirculation zones within the gap with sufficient energy to erode the surrounding metal potentially leading to bit washout.

It is an object of this invention to provide a nozzle retention device that will increase the fluid flow capacity through a nozzle.

SUMMARY OF THE INVENTION

According to this invention there is provided a nozzle retention device for the retention of replaceable fluid nozzles within the body of a rock bit, where a first upstream end of the nozzle retention device communicates with a fluid plenum formed by said bit body, a second downstream end of the nozzle retention device being adapted to receive said fluid nozzles, said nozzle retention device having an arcuate fluid entrance at said first upstream end, said arcuate entrance beginning at an outer peripheral edge formed by said first upstream end and proceeding inwardly toward a straight bore section of said nozzle retention device positioned intermediate said first and second ends, whereby the arcuate fluid inlet serves to increase the flow of fluid to the nozzles, reduce turbulence of the fluid and substantially reduce the erosive effects associated with high velocities and turbulent flow.

In one embodiment the arcuate fluid entrance at said first upstream end is parabolic in shape. In an alternative embodiment the arcuate fluid entrance is elliptical in shape.

Preferably said nozzle retention means is a sleeve that is secured within the body of said rock bit.

Advantageously the surface formed by the upstream end of said sleeve in use in contact with a drilling fluid contained within said plenum is made of a material that is more wear and erosion resistant than the material of a downstream portion of said sleeve. In one embodiment the surface material of said upstream end of said sleeve is tungsten carbide. Advantageously the downstream portion of said sleeve is made of steel.

Advantageously the arcuate fluid entrance at said first upstream end is about one quarter of a circle.

In a currently preferred embodiment the ratio between the first upstream end and said straight bore section is from 1.75 to 10.0.

Conveniently the nozzle retention device is machined directly within the body of said rock bit. In another embodiment the nozzle retention device is formed within a sleeve that is arranged to be extended beyond the rock bit body such that said replaceable nozzle may be positioned a desired distance from a borehole bottom for efficient removal of detritus from said borehole bottom.

A streamlined fluid entrance is formed at the first upstream end of the nozzle sleeve. The streamlined entrance is generally rounded or elliptical. The rounded or elliptical fluid entrance is formed at the first upstream end of the nozzle sleeve. The rounded or elliptical entrance begins at an outer peripheral edge formed by the first upstream end of the sleeve and proceeds inwardly toward a straight bore section formed by the sleeve and positioned about intermediate the first and second ends of the sleeve. The rounded or elliptical fluid inlet formed by the sleeve serves to increase the flow capability of fluid to the nozzles by reducing separation of the fluid which substantially reduces the erosive effects associated with high fluid velocities.

The weld-in sleeve of the present invention increases

the fluid flow capacity through a replaceable nozzle by increasing the entrance flow area and by reducing geometrical discontinuities into the jet nozzle.

One of the design approaches resulted in a sleeve with an upstream rounded or elliptical entrance that blends into a straight bore section that interfaces with the nozzle receptacle. The sleeve is intalled (welded) in a straight bore hole formed in the bit body that proceeds from an external surface of the leg forging into the internal jet bore plenum formed by the bit body.

The straight bore section of the nozzle sleeve may be shortened or lengthened to move an exit plane of the nozzle closer to or further from a borehole bottom to improve bottom hole cleaning .

An alternative approach is to provide an erosion resistant material that extends into the jet bore plenum to shield high fluid velocity areas from erosion. Still another alternative approach is to provide an erosion resistant material that is rounded or elliptical at the entrance to the weld-in sleeve that will resist erosion while providing increased fluid flow capacity to the nozzle.

It is an advantage then over the prior art to provide increased fluid flow to the nozzles by providing a weld-in sleeve with a rounded or elliptical fluid entrance to the nozzles.

It is yet another advantage over the prior art to provide a weld-in sleeve that may be shortened or lengthened to locate a nozzle exit plane closer to or further from a borehole bottom to enhance the removal of detritus from the borehole bottom.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a rotary cone rock bit with emphasis on one of the fluid nozzles,

Figure 2 is a partially broken away cross-section of

a prior art nozzle sleeve welded into a bit leg forging aperture,

Figure 3 is a cross-section of a nozzle sleeve of the present invention welded or mounted within a straight bore formed in a bit leg forging,

Figure 4 is a cross-section of an extended nozzle sleeve of the present invention welded within a straight bore formed in a bit leg,

Figure 5 is a cross-section of an alternative nozzle sleeve wherein a rounded inlet to the sleeve is formed from an erosion resistant metal, and

Figure 6 is a cross-section of an alternative nozzle sleeve configuration wherein a wear and erosion resistant liner is positioned in an inlet orifice leading to the nozzle sleeve; an entrance to the liner extending into a plenum formed by the rock bit body.

In the Figures, like reference numerals denote like parts.

DESCRIPTION OF THE PREFERRED EMBODIMENTS AND BEST MODE FOR CARRYING OUT THE INVENTION

With reference to Figure 1, the rotary cone rock bit generally designated as 10 consists of rock bit body 12, pin end 14 and a cutting end generally designated as 16. A fluid chamber or plenum 13 is formed within bit body 12. The plenum 13 communicates with the open pin end 14 so that hydraulic fluid (mud) may enter the rock bit body through an attached drill string (not shown). A dome 17 formed by the bit body defines a portion of the fluid plenum 13 (Figs. 2 and 3). Rock bit legs 20 extend from the bit body 12 toward the cutting end 16 of the bit. A cutter cone 18 is rotatively secured to each leg 20 through a journal bearing extending into each cone from a shirtail 22 of the leg 20 (not shown).

Each cone 18, for example, has a multiplicity of cutter inserts 19 equidistantly spaced around each of the cones 18.

A lube reservoir system 24 supplies a lubricant to

bearing surfaces defined between the interior of the cones 18 and the journal.

A mini-extended nozzle generally designated as 2 is shown protruding from a nozzle retention sleeve generally designated as 30 (Fig. 3). The mini-extended nozzle is the subject of a related patent application entitled COMPOSITE NOZZLES FOR ROCK BITS filed October 4, 1994 under U.S. Serial No. 317,969 and assigned to the same assignee as the present invention.

The prior art of Figure 2 depicts a counter bore aperture 3 formed in leg forging 20 that communicates with plenum 13. A straight bore 3 is drilled into plenum 13 followed by a counterbore 4 that terminates at shoulder 5 in nozzle retention body 15. The plenum entrance to straight bore 3 creates a sharp corner 7 as well as a reduced-in-area entrance to the standard nozzle sleeve generally designated as 8.

The reduced diameter entrance increases the mud flow velocities into the entrance to nozzle sleeve 8 thus accelerating any erosion that may occur.

Moreover, the sharp corners 7 creates fluid flow separation and high shear layer stresses as well as adding to the erosive capabilities of the fluid.

The current weld-in sleeve 8, for example, for a 31.1cm (12¼ inch) bit (D_t = 3.18cm (1.25 inch), D_n = 2.69cm (1.06 inch)) has a A_t/A_n ratio of 1.39 (where $A_t = \Pi \frac{D_t^2}{4}$ and $A_n = \Pi \frac{D_n^2}{4}$ while the new high flow sleeve 30 (D_t = 4.4cm (1.75 inch), D_n = 2.69cm (1.06 inch))has a A_t/A_n ratio of 2.73 (see Fig. 3).

Turning now to the preferred embodiment of Figure 3, the new sleeve design generally designated as 30 lowers the entrance velocity by machining a larger straight bore hole 32 in the sleeve retaining body 15 formed by bit body 12 to

the plenum 13. By manufacturing, for example, an elliptical shaped surface 36, high efficiency entrance 35 in the sleeve 30, the sleeve now takes full advantage of the larger straight bore 32 in bit body 12. Entrance 35 leads to elliptical contour 36 that tangents an internal straight bore 39 formed by sleeve body 31, entrance 35 and exit plane 37.

The sleeve, for example, is welded at the juncture 29 formed between the exit end 37 of the sleeve 30 and the straight bore opening in the sleeve retention body 15 of bit 10.

By reducing the entrance velocity by increasing the entrance diameter (D_t), higher mud fluid flow rates can be passed through the sleeve 30 without risk of erosion. The more desirable A_t/A_n ratio of 2.73 corresponds to a reduced entrance fluid velocity of 50% over the current weld-in sleeve design (sleeve 8 in Fig. 2), assuming D_n is the same for both sleeves and equals 2.69cm (1.06 inch).

The A_t/A_n ratio for weld in sleeves may range from 1.75 to 10 without departing from the teaching of this invention.

Furthermore, gap areas created by improper placement of the state of the art sleeves 8 during the weld-in process is eliminated. Since all interface gaps between the sleeve design 30 and the machined straight bore 32 in bit body 12 are located at relatively low fluid flow velocity areas 35, eddy current erosion is decidedly minimized.

It would be obvious to form elliptical entrance 36 into other shape such as a quarter round or parabolic without departing from the scope of this invention.

It would also be obvious to machine the entrance 25, the elliptical contour 36 and the internal straight bore 39 directly into the bit body 15 without departing from the scope of this invention.

With reference now to Figure 4, an alternative embodiment extended nozzle sleeve generally designated as

40 forms an entrance 45 that transitions into elliptical portion 46 that in turn tangents on internal straight bore 49 formed by sleeve body 41. The exit plane 47 may be extended distance 'A'; the length of the extension depending upon the desired distance the exit of the nozzle is with respect to a borehole bottom (not shown) to effect the best bottom hole cleaning by the nozzle 2 (Fig. 1).

The extended nozzle sleeve 40 is welded at the juncture 29 formed between the outer surface of the sleeve and the straight bore opening in the sleeve retention body 15.

Referring now to Figure 5, another alternative embodiment of the nozzle sleeve generally designated as 50 is depicted wherein a erosion resistant segment 52 forms the upstream end surface of the nozzle sleeve 50. The erosion resistant segment 52 is preferably formed of tungsten carbide. Segment 52 forms entrance 55 that leads to elliptical contour 56 that tangents straight bore section 59 of sleeve body 53.

Typically the nozzle sleeve body 53 (as well as the nozzle sleeve bodies of Figs. 2 to 4) is fabricated from steel and the tungsten carbide is metalurgically bonded to the steel at interface 58.

An obvious means to join the carbide segment 52 to the steel sleeve is to braze the segment to the steel body 53.

The nozzle sleeve designs illustrated with respect to Figs. 3 to 5 adapts well to placing the nozzle receptacle closer to the formation borehole bottom while maintaining a robust design. The internal straight bore hole section 39, 49 and 59 can be increased or decreased in length during manufacturing to move the nozzle exit closer to the borehole bottom as shown in Figure 4. This unique feature may be used to enhance bottom hole cleaning without using large carbide pieces (like mini-extended nozzles) or long cantilevered nozzles such as full extended nozzle tubes (not shown).

A protective modification is depicted with respect to Figure 6 wherein an erosion resistant extended liner or sleeve 64 is secured, for example, by brazing the liner at an interface 68 formed between the sleeve body 63 and the liner 64. The upstream end 66 of the liner 64 extends into the plenum 13 such that the drilling fluid is accelerated over the erosion resistant end 66 thus moving the increased flow away from the vulnerable steel rock bit components subject to erosion. End 65 of liner 64 is recessed in a groove 63 formed in upstream end 62 of nozzle sleeve 60. Again, the sleeve 60 is welded at juncture 29 formed between exit 67 of sleeve body 61 and the bore 70 in sleeve retention body 15 of bit 10.

It would be obvious to apply this present invention to flow passages in fixed cutter type rock bits (not shown) as well as roller cone rock bits.

It will of course be realized that various modifications can be made in the design and operation of the present invention without departing from the spirit thereof. Thus while the principal preferred construction and mode of operation of the invention have been explained in what is now considered to represent its best embodiments which have been illustrated and described, it should be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically illustrated and described.

CLAIMS:

1. A nozzle retention device for the retention of replaceable fluid nozzles within the body of a rock bit, where a first upstream end of the nozzle retention device communicates with a fluid plenum formed by said bit body, a second downstream end of the nozzle retention device being adapted to receive said fluid nozzles, said nozzle retention device having an arcuate fluid entrance at said first upstream end, said arcuate entrance beginning at an outer peripheral edge formed by said first upstream end and proceeding inwardly toward a straight bore section of said nozzle retention device positioned intermediate said first and second ends, whereby the arcuate fluid inlet serves to increase the flow of fluid to the nozzles, reduce turbulence of the fluid and substantially reduce the erosive effects associated with high velocities and turbulent flow.

2. A device as claimed in claim 1 wherein the arcuate fluid entrance at said first upstream end is parabolic in shape.

3. A device as claimed in claim 1 wherein the arcuate fluid entrance is elliptical in shape.

4. A device as claimed in any preceding claim wherein said nozzle retention means is a sleeve that is secured within the body of said rock bit.

5. A device as claimed in claim 4 wherein the surface formed by the upstream end of said sleeve in use in contact with a drilling fluid contained within said plenum is made of a material that is more wear and erosion resistant than the material of a downstream portion of said sleeve.

6. A device as claimed in claim 5 wherein the

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surface material of said upstream end of said sleeve is tungsten carbide.

7. A device as claimed in claim 5 or 6 wherein the downstream portion of said sleeve is made of steel.

8. A device as claimed in any preceding claim wherein the arcuate fluid entrance at said first upstream end is about one quarter of a circle.

9. A device as claimed in any preceding claim wherein the ratio between the first upstream end and said straight bore section is from 1.75 to 10.0.

10. A device as claimed in any preceding claim in combination with a rock bit wherein the nozzle retention device is machined directly within the body of said rock bit.

11. A device as claimed in claim 1 wherein the nozzle retention device is formed within a sleeve that is arranged to be extended beyond the rock bit body such that said replaceable nozzle may be positioned a desired distance from a borehole bottom for efficient removal of detritus from said borehole bottom.

12. A nozzle retention device substantially as herein described, with reference to and as shown in each of the embodiments of Figures 3-6.