

HAMMER ROCK BIT GAGE PROTECTION

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates to a hammer ROCK drill bit.

More particularly, this invention relates to the cutting end of the hammer bit and a means to maintain the gage diameter of the borehole while the hammer bit works in an earthen formation.

BACKGROUND

In percussion drilling the rock cutting mechanism is of an impacting nature rather shearing commonly associated with diamond drag bits. Therefore, the drill bit rotational parameters, e.g. torque and rpm, are not relevant from a rock formation breaking point of view, except for the necessity that the cutting elements of the bit need to be " indexed " to fresh rock formations. In straight hole air drilling, and especially in mining, this need is achieved by rotating the drill string slowly. This is accomplished in hammer bit operations by incorporating longitudinal splines which key the bit body to a cylindrical sleeve at the bottom of the hammer housing [commonly known as the sub driver]. The drill string rotation is then transferred to the hammer bit itself.

Experience has proven that the bit optimum rotational speed is approximately 4 to 5 degrees per impact of the bit against the rock formation. Another way to express this rotation is the cutters positioned on the outer row of the cutting end of the hammer bit move at a rate of one half the cutter diameter per stroke of the hammer mechanism.

An example of a typical hammer bit connected to a rotatable drill string is described in U.S. Pat. No. 4,932,483. The downhole hammer comprises a top hammer mechanism sub and a drill hammer bit separated by a tubular housing incorporating a piston chamber there between. A feed tube is mounted to the top sub and extends concentrically into the piston chamber. Fluid porting is provided in the feed tube and the piston to sequentially

admit fluid in a first space between the piston and top sub to drive the piston towards the drill bit shank and to a second space between the piston and the drill bit shank to drive the piston toward the top sub.

Rotary motion is provided to the hammer assembly and drill bit by the attached drill string powered by a rotary table typically mounted on the drill platform.

The hammer bit is thus advanced in a borehole. If however, the bit should diametrically wear, the borehole diameter will get progressively smaller in diameter as the worn hammer bit is further advanced in the borehole requiring that a separate reaming operation be performed before a new, full diameter hammer bit is connected to the hammer sub to further advance the hammer bit in the earthen formation.

U. S. Patent No. 3,346,060 attempts to address the undergage problem by providing spaced rows of side wall carbide cutters above the gage row of carbide cutters. The bit includes a body portion forming a horizontal cutter face and vertical cylindrical walls. A multiplicity of carbide inserts are positioned in the cutting face and a series of carbide gage inserts are spaced around the perimeter of the bit. Two rows of carbide cutters are additionally inserted in the cylindrical side wall of the bit, each cutter insert being oriented at an oblique angle to an axis of the bit to help maintain the gage diameter of the bit.

Since the side wall inserts are fabricated from the same carbide material that the gage row and cutter face inserts are fabricated from, they will wear at substantially the same rate as the bit works in a borehole thus, the bit will wear undergage despite the side wall protection.

The present invention provides a means to prevent or minimize degradation of the gage diameter of the hammer bit as the bit is advanced in the earthen formation.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved hammer cutter bit that will maintain its gage diameter.

According to this invention there is provided A hammer rock drill bit having a first cutter end formed by a bit body, a cutter face formed by said cutter end containing a plurality of tungsten carbide inserts, a peripheral edge of said cutter end containing a plurality of spaced tungsten carbide gage row inserts extending beyond said edge of said cutter end to a predetermined gage diameter of said cutter end of said hammer bit, said hammer rock drill bit body forming a second splined base end, said second base end is contained within a reciprocating hammer drill bit subassembly, said first cutter end having gage row cutter back up means formed thereon to maintain the bit gage diameter as the bit works in an earthen formation after the tungsten carbide gage row inserts wear causing the gage row diameter through a plane taken through the gage row inserts go undergage, said backup means to maintain said gage diameter comprises:

at least a pair of diamond cutters mounted to a side wall formed by said first cutter end above and longitudinally spaced from said tungsten carbide gage row inserts, said diamond cutters project axially from said side wall out to a gage diameter of said hammer bit, said diamond cutters serve to maintain the gage of the hammer bit after the less hard tungsten carbide gage row inserts wear undergage thereby maintaining the full gage of the hammer bit through a plane of said diamond cutters positioned above the worn tungsten carbide gage row inserts.

A hammer rock drill bit is disclosed having a first cutter end, a cutter face formed by the cutter end and a splined shank adapted to be connected to an air hammer sub. The cutter face contains a plurality of equidistantly spaced gage row inserts that extend beyond the edge of the

cutter end to a predetermined gage diameter of the hammer bit. The first cutter end additionally has gage row cutter back up mean formed thereon to maintain the bit gage diameter as the bit works in an earthen formation. After the gage row inserts wears, the gage row diameter through a plane taken through the gage row inserts will be undergage. The backup means to maintain the gage diameter after the gage row inserts wear consists of at least a pair of ultra-hard cutters mounted to a side wall formed by the first cutter end below and longitudinally spaced from the gage row inserts. The ultra-hard cutters project axially from the side wall out to a gage diameter of the hammer bit. The ultra-hard cutters serve to maintain the gage of the hammer bit after the gage row inserts wear undergage thereby maintaining the full gage of the hammer bit through a plane of the ultra-hard cutters positioned below the worn gage row inserts.

The use of a plurality of hemispherical polycrystalline diamond enhanced inserts equidistantly spaced around the hammer bit body above the gage row inserts has proven to maintain the gage diameter of the bit despite wear of the cutters on the face of the bit and the gage row inserts spaced around the perimeter of the bit face as the hammer bit works in a borehole.

The diamond enhanced inserts are installed perpendicular to the axis of the hammer bit. The enhanced inserts are, for example, pressed within insert holes formed in the cylindrical side wall of the hammer bit body such that their diameter is $+0 - .010$ of gage [diameter]

The number of diamond enhanced gage maintenance inserts depends upon the size of the hammer bit, earthen formation and customer needs. Generally however, the number of diamond inserts should be about half the number of gage row inserts located around the peripheral edge of the cutting face of the hammer bit.

The gage protection, diamond enhanced insert wear

resistance is about one thousand times more than tungsten carbide. The diamond enhanced inserts do not wear undergage and only a few inches of the borehole will be undergage if the tungsten carbide gage row inserts should wear on the face of the hammer bit. Since these few inches can be easily removed by the following hammer bit, drilling may continue with no interruptions to ream an undergage borehole.

An advantage then of the present invention over the prior art is the use of a plurality of diamond enhanced inserts in the cylindrical wall of a hammer bit to maintain the bit gage as the bit works in a borehole.

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 side view of a prior art hammer bit without the diamond gage protection;

Figure 2 is a side view of the preferred embodiment of the present invention illustrating the hammer reciprocating sub in phantom line;

Figure 3 is an end view taken through 3-3 of Fig. 2 illustrating the gage row inserts around the periphery of the cutting face of the bit;

Figure 4 is an enlarged cross-section of the present invention illustrating the relationship of the gage row inserts with respect to the hemispherical diamond enhanced gage protection inserts protruding from the hammer bit side wall;

Figure 5 is a cross-section taken through 5-5 of Fig. 4 illustrating the enhanced polycrystalline diamond inserts mounted within insert retention holes formed in the body of the hammer bit ninety degrees to an axis of the bit, and

Figure 6 is a partial cross-section of a hemispherical polycrystalline diamond enhanced insert that is preferably utilized in the cylindrical side wall of the hammer bit.

In the figures like reference numerals denote like

parts.

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

With reference now to the prior art of Figure 1, the standard hammer bit generally designated as 1 consists of bit body 2, shank 3, splines 4 and a cutter head generally designated as 5. Cutter head 5 forms cutter face 6, the cutter face including a multiplicity of tungsten carbide inserts 7 interfitted within insert holes formed in the face of the cutter head. The outer peripheral edge of the cutter head 5 contains gage row tungsten carbide inserts 8, the purpose of which is to maintain the gage or diameter of a borehole constant throughout the length of the borehole [see 32, Fig. 2]. A series of longitudinal slots 9 are typically formed equidistantly spaced around the cylindrical side wall of the hammer bit 1. The purpose of the slots 9 is to provide a means for the debris containing fluid to escape past the cutter head to the rig floor [not shown].

As heretofore stated the tungsten carbide gage row inserts 8 wear away as the state of the art hammer bit 1 works in a borehole causing the bit to bore an undergage borehole resulting in a separate reaming operation followed by replacement of the worn bit with a new full gage hammer bit; an expensive and time consuming operation.

Figure 2 depicts a preferred embodiment of the invention wherein the hammer bit generally designated as 10 consists of bit body 11, shank 12, splines 13 and a cutter head generally designated as 14. The cutter head 14 forms cutter face 15, the cutter face containing a multiplicity of tungsten carbide inserts 16 [typically dome or hemispherically shaped] interfitted within insert retention holes formed in the face of the cutter head 14. The outer peripheral edge 18 of the cutter head 14 contains gage row tungsten carbide inserts 17, again the purpose of the gage row inserts is to maintain the gage of a borehole 32 throughout the length of borehole. A series of

longitudinally disposed slots 22 are about equidistantly spaced around the side wall of the cutter head 14. The slots provide a means for the fluid and borehole detritous to move from the bottom 34 of the borehole 32 to the rig floor.

The longitudinal surfaces 23 between the slots 22 provide a means to mount a plurality of ultra-hard gage trimming inserts generally designated as 20. These ultra-hard inserts are preferably hemispherical transition layer polycrystalline diamond inserts manufactured by Megadiamond Industries, a division of assignee Smith International Inc., and covered by U. S. Patent Numbers 4,604,106 and 4,694,918, all of which are incorporated herein by reference.

Inserts 20 are located about midway along the length of surfaces 23 and preferably are positioned on every other surface 23. In other words, there are half as many diamond gage trimmer inserts 20 as there are gage row inserts 17 mounted on the peripheral edge 18 of the cutter head 14. The extension of each of the inserts 20 is $+0 - .010$ of the extension of each of the gage row inserts 17. The purpose of the diamond gage trimmers 20 is to maintain the gage diameter of the hammer bit 10 hence the diameter of the borehole should the gage row tungsten carbide inserts 17 wear undergage.

It would be obvious of course to utilize spherical diamond inserts 20 on each of the surfaces 23 without departing from the scope of this invention.

With reference now to Figures 3 and 4 the face 15 of the cutter head 14 contains a multiplicity of, for example, rounded of "button" tungsten carbide inserts that are typically interfitted or pressed within insert sockets 19 formed in the face of the cutter head. The gage row inserts 17 are fabricated from tungsten carbide as well and are equidistantly spaced around the peripheral edge 18 of the cutter head 14. The gage insert retention sockets 27 are drilled at an oblique angle to an axis 29 of the hammer

bit 10 to direct the rounded cutting surface of the insert 17 beyond edge 18 to maintain the desired gage diameter of the borehole.

Tungsten carbide inserts are tough, hard and abrasion resistant and for this reason, are used in the cutter head of hammer bits. The tungsten carbide inserts are especially resistant to fracturing due to the impact and rotational forces imparted to the bit as it works in a borehole. There are many grades of tungsten carbide that range in differing hardness and toughness values. A relatively soft but tough tungsten carbide insert would have a ratio of about 10 percent cobalt mixed with tungsten carbide, the tungsten carbide particles being relatively large in grain size.

A typical and preferred tungsten carbide button type insert for hammer bit applications would have a ratio of about 6 percent cobalt with the remainder of tungsten carbide having a relatively fine grain particle sizes. These tungsten carbide inserts have a knoop hardness value of about 1500.

As a comparison, polycrystalline diamond inserts used in the present invention as a gage trimmer has a knoop hardness value from 5000 to 8000.

Diamond inserts such as polycrystalline diamond insert cutters are much harder than tungsten carbide however diamond is very brittle hence has less impact resistance therefore most diamond inserts are unsuitable for the impact cutting face of hammer bits. Polycrystalline diamond hemispherical inserts are suitable for gage trimming environments since the cutting end of the insert is utilized in a shear mode rather than an impact mode.

Figure 5 illustrates the diamond inserts 20 with the stud body 21 inserted within insert socket 31 formed in surface 23 of cutter head 14. An axis of the socket 31 is about ninety degrees to axis 29 of bit 10. Each of the diamond inserts 20 then come into shear contact with borehole wall 36 of borehole 32 should the tungsten carbide

gage inserts wear undergage.

A trip out of the borehole 32 to replace a worn hammer bit incorporating the novel diamond gage trimmers, requires that the new hammer bit ream only the short undergage longitudinal distance from the gage inserts 17 to the diamond gage trimmer inserts 20 [a few inches at most]. This is easily accomplished with the new diamond gage trimmer equipped hammer bit 10 without the use of a special borehole trimmer tool application thus saving time and money wasted in "tripping" in and out of the borehole.

Figure 6 depicts a hemispherical polycrystalline diffusion layer insert 20 patented by the assignee that is preferably utilized in surface 23 of cutter head 14. The insert consists of a tungsten carbide stud base 21 with a diamond diffusion layer 25 making up the cutting / gage trimming end of the insert 20.

Other types of diamond cutter may be used in surface 23 of the cutter head 14 of hammer bit 10 without departing from the scope of this invention.

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 hammer rock drill bit having a first cutter end formed by a bit body, a cutter face formed by said cutter end containing a plurality of tungsten carbide inserts, a peripheral edge of said cutter end containing a plurality of spaced tungsten carbide gage row inserts extending beyond said edge of said cutter end to a predetermined gage diameter of said cutter end of said hammer bit, said hammer rock drill bit body forming a second splined base end, said second base end is contained within a reciprocating hammer drill bit subassembly, said first cutter end having gage row cutter back up means formed thereon to maintain the bit gage diameter as the bit works in an earthen formation after the tungsten carbide gage row inserts wear causing the gage row diameter through a plane taken through the gage row inserts go undergage, said backup means to maintain said gage diameter comprises:

at least a pair of diamond cutters mounted to a side wall formed by said first cutter end above and longitudinally spaced from said tungsten carbide gage row inserts, said diamond cutters project axially from said side wall out to a gage diameter of said hammer bit, said diamond cutters serve to maintain the gage of the hammer bit after the less hard tungsten carbide gage row inserts wear undergage thereby maintaining the full gage of the hammer bit through a plane of said diamond cutters positioned above the worn tungsten carbide gage row inserts.

2. The invention as set forth in claim 1 wherein the diamond cutters are polycrystalline diamond.

3. The invention as set forth in claim 3 wherein the polycrystalline diamond is bonded to a tungsten carbide stud insert body, said stud body is interfitted within an insert hole formed in said side wall of said first cutter end.

4. The invention as set forth in claim 4 wherein an axis of said stud insert body is about ninety degrees to an



axis of said hammer rock bit.

5. The invention as set forth in claim 5 wherein a cutter end of said polycrystalline diamond insert is spherically shaped.

6. The invention as set forth in claim 1 wherein the number of diamond gage row cutter back up means mounted to said side wall of the cutter end is about equal to the number of tungsten carbide gage row inserts contained within said peripheral edge of the cutter face.

7. The invention as set forth in claim 6 wherein the number of diamond gage row cutter back up means mounted to said side wall of the cutter end is about half of the number of tungsten carbide gage row inserts mounted in said peripheral edge of said cutter face.

8. A hammer rock drill bit substantially as herein described with reference to and as shown in Figures 2-6 of the accompanying drawings.