A METHOD FOR MAINTAINING HOLE GAUGE: CASE HISTORIES IN THE PERMIAN BASIN

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ABSTRACT

Maintaining hole gauge has always been a drilling concern and problem. Historically gauge protection above the bit has been accomplished by using hard metals that offer good wear resistance. There are limitations to this method for actually sustaining a quality gauge hole. Other methods for accomplishing a gauge hole are mechanical devices placed in the drilling assembly, such as reamers. These tools also have limitations in directional applications and hostile environments.

This paper will discuss the development of a tool that strategically places Synthetic Diamond Enhanced Inserts to accomplish both hole gauge protection and reaming. The performance of this tool will be economically evaluated with offset data for a direct comparison to the drilling curve and the benefit it derives.

INTRODUCTION

Protecting the gauge of the hole during the drilling process has long been an area for concern and address. When a bit goes undergauge, a compounding problem is created in the drilling process. Unless the problem is rectified by reaming the hole to gauge, the problem will persist through the rest of the drilling process. This progression takes place as the next bit is tripped in the hole. A portion of that bits usable life is used in reaming the drilled hole to usable gauge before new hole can be drilled. This reduces the footage obtained by the new bit, thus requiring more bits to drill the total depth of the well in a longer time period, resulting in higher drilling costs.

Outside the scope of the bit itself, two tools have been developed to maintain hole gauge during the drilling process. First is a reamer.' In an environment where maintaining hole gauge is a problem, a reamer is placed above the bit. Reamers are mechanical tools with small contact areas against the borehole and equipped with a cutting structure. The cutting structure is placed on the OD of smaller rollers, which are fixed to the OD of a larger tool. (Figure 1) As the larger OD tool rotates, the smaller rollers cut the hole to the proper gauge. However, with the added complexity of moving parts, the applications for this tool are limited, especially in more hostile drilling environments. It should also be noted that reamers do not give proper stabilization of the Bottom Hole Assembly (BHA), and thus a stabilizer would still be required as determined with the proper BHA analysis.[2]

Stabilizers are also used to protect hole gauge during drilling, but do not employ structures in a fashion to cut formation, rather, provide surfaces for gauge retention using abrasion resistant material. The formation being drilled will dictate what material should be placed on the stabilizer. The abrasion resistant material most commonly used is tungsten carbide. Tungsten carbide has the versatility to be shaped into geometric forms for specific applications and provides a consistent wear resistance. Weld on hard facing is also a popular choice for stabilizers. The wear resistance far exceeds that of tungsten carbide, but the wear depth is limited to the thickness which it is applied to the blades.

SYNTHETIC DIAMOND ENHANCED INSERT (SDEI)

To create the SDEI, crystals of the polycrystalline diamond are sintered onto the tungsten carbide substrate in a geometry specific to the application. Through this process, three layers are produced within the material, a diamond layer, cobalt, and tungsten carbide (Figure 2), where the transition zone encasing all three materials is gradual. Consequently, the change in thermal and elastic properties becomes more gradual. This improves the fatigue strength, compressive strength, and impact resistance of the insert, while giving it a greater ability to dissipate heat compared to single layer inserts where no transition zone exists. These enhanced physical properties improve the durability of the cutter make it ideal for placement to maintain gauge in drilling.[3,4]

Development of geometric inserts evolved simultaneous to the SDEI material as described above. Applications in harder formations as encountered in west Texas, required a semi-round geometry. Analysis of bit performance where the gauge row was equipped with the semi-round geometry provided exceptional performance in harder formations due the crushing characteristics it exhibits during drilling. In the application for the-design of this tool, this geometry was ideal.[5]

DESIGN AND CONCEPT

It was identified that in areas where gauge maintenance was a problem, there needed to be a tool that could maintain gauge like a near bit stabilizer, yet have a cutting structure to effectively ream hole as required. Initially the SDEI were applied to an Integral Blade Stabilizer (IBS). Operationally, excessive torque and drag in this design was observed. This design evolved to a straight bladed sub placed directly behind the bit. Original designs employed a fishing neck used for make up and break out of the tool. Again, operationally this design negatively impacted directional performance due to its length. Finally, a short, compact tool with straight blades was designed. (Figure 3)

In the final design, the bit box was designed to optimize the placement of the SDEI's directly behind the bit. This also allowed the length of the tool to be shortened and eliminate problems noted in earlier designs with directional performance. It also fits most bit types, both roller cone and PDC.

Downhole hydraulics was also taken into consideration during the designing of the tool. It was imperative to optimize the flow by the tool, *to* maintain optimum hydraulics at the bit face. Restrictions would negatively impact annular flow and pressure.

Placement and retention of the SDEI within the blade structures is also crucial to tool performance. Therefore, precisely machined holes using a CNC machine are used for this process. Retention of the inserts in the machined holes is done using a low temperature silver solder, which provides a strong bond to the parent material. Initial application and subsequent repair of the SDEI is maintained in a highly controlled environment performed by trained technicians.[6]

Due to the compact design of the component, a method for make up and break out was required. Emulating the design of the bit breaker, Figure **4** shows the device used to perform this function. Each tool has a breaker, which is sent to the rig with it to perform these functions.

CASE HISTORIES

Bloxom #1

The first run was initiated at a depth of 3,953 ft. with the objective of maintaining hole gauge. Formations encountered during the 82 hour run over 3,204 ft., were shale and limestone. There was zero footage that required reaming. Figures 5 and 6 show the sub after this run. Analyzing the inserts from bottom *to* top, a taper in insert wear is evident. Increased torque was seen at the surface toward the end of the bit run, indicating the sub was having to work harder to drill the hole to the gauge. Another advantage of utilizing this system, as an indicator to pull the bit when gauge is lost. Figure **7** shows the bit after this run.

BHA
-8.75" Bit
-8.75" DOG Sub
-Motor
-X-over
-3 Pt. Reamer
-One 6.50" OD DC
-3 Pt. Reamer
-Fifteen 6.50" OD Spiral DC
-Jars
-Thirteen 6.50" OD Spiral DC
-Nine 4.50" HWDP

The second run drilled 1,698 ft. from an initial depth of 7,157 ft. and requiring 48.5 hours to complete. Formations encountered on this run were shale, limestone, and chert. No reaming was required. Figure 8 shows the sub after the run. The wear pattern on the inserts is very even. Displayed in Figure **9** is the bit after this run.

BHA
-8.75" Bit
-**8.75**" DOG Sub
-Motor
-X-over
-3 Pt. Reamer
-One 6.50" OD DC

-3 Pt. Reamer
-Fifteen 6.50" OD Spiral DC
-Jars
-Thirteen 6.50" OD Spiral DC
-Nine 4.50" HWDP

Dooley #1

The first run with the DOG sub on the Dooley #1 well was in conjunction with bit numbers six and seven. With bit number six, a total footage of 841 ft. was obtained in 47.5 hours starting from 9,860 ft. An additional 1,096 ft. was drilled in 83 hours with bit number seven. Combined, the assembly drilled 1,937 ft. in 130.5 hours ending at a depth of 11,554 ft. No reaming was required on either trip.

BHA
-12.25" Bit
- 12.25" DOG Sub
-Motor
-3 Pt. Reamer
-One 9" OD DC
-3 Pt. Reamer
-Remainder 9" and 8" OD Spiral DC

Bit number 11 and 15 were run with the same DOG sub. Starting at 13,451 ft. with bit number 11, 938 ft. was drilled through shale and limestone in 98 hours. The second trip was made with bit number 15 starting at 15,461 ft., which drilled 252 ft. in 46 hours. Adding the two runs together produced 1,190 ft. of drilled hole in 144 hours that required no reaming.

BHA
-8.500" Bit
-8.500" DOG Sub
-Motor
-X-over
-IBS
-29 - 6.50" OD DC
-Jars
-Six 6.50" OD DC
- X-over
-5.0" DP

CONCLUSIONS

In harder formations, the ability to maintain hole gauge can drastically impact the drilling curve. It was concluded through field runs that strategic positioning of SDEI directly behind the bit provides gauge protection, while maintaining the capacity to ream the hole. By eliminating the mechanical components in the assembly, there are no components to fail and be left in the hole. Because the tool is unaffected by the drilling medium, it is ideal for underbalance drilling and drilling in harsh environments. The near bit application of the tool design provides stabilization to the BHA, which in turn enhances bit performance and life through reduced vibration[7]

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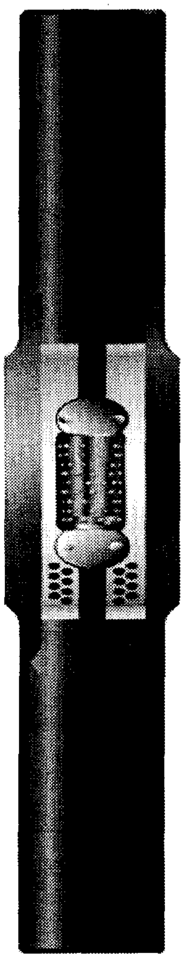


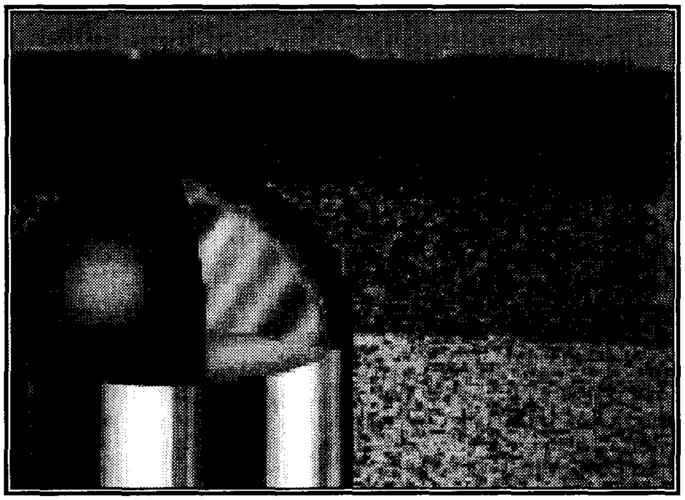
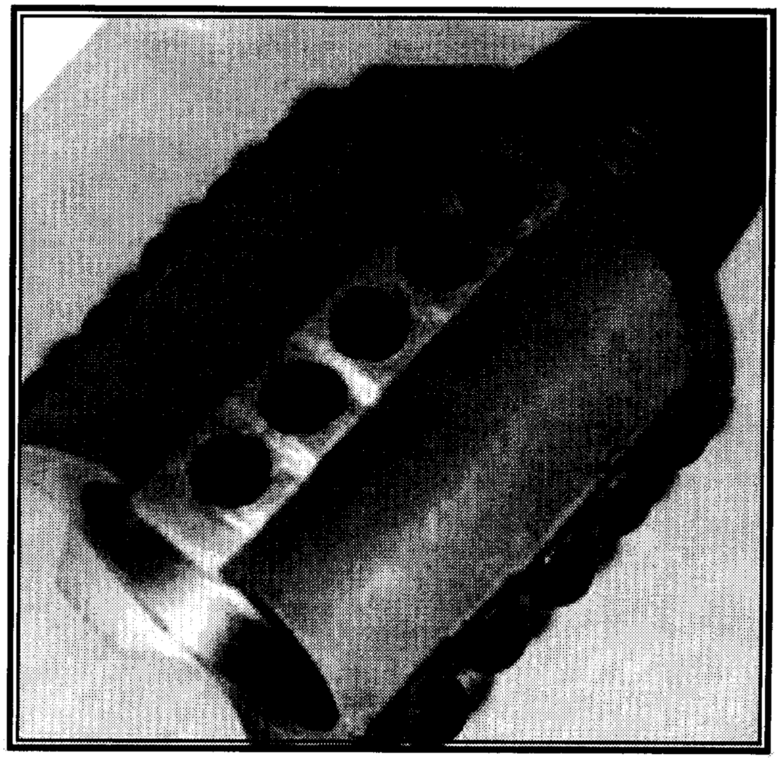


Figure 2

Figure 1



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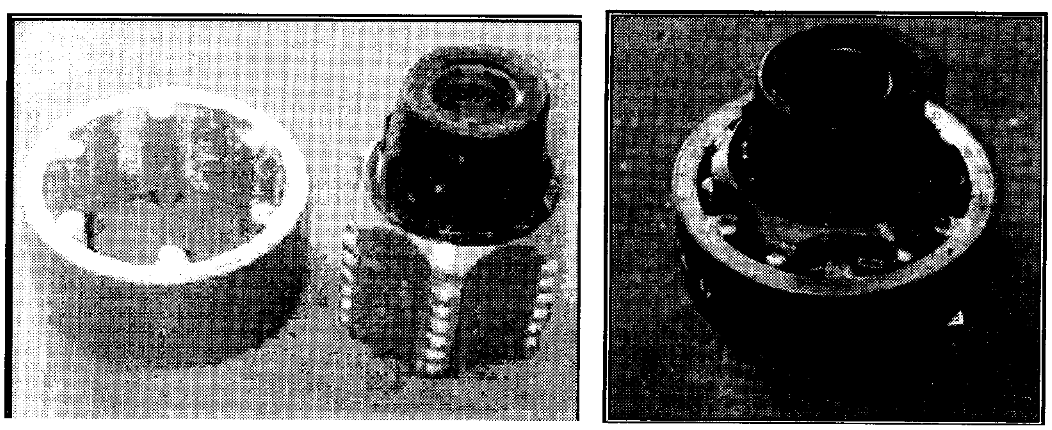

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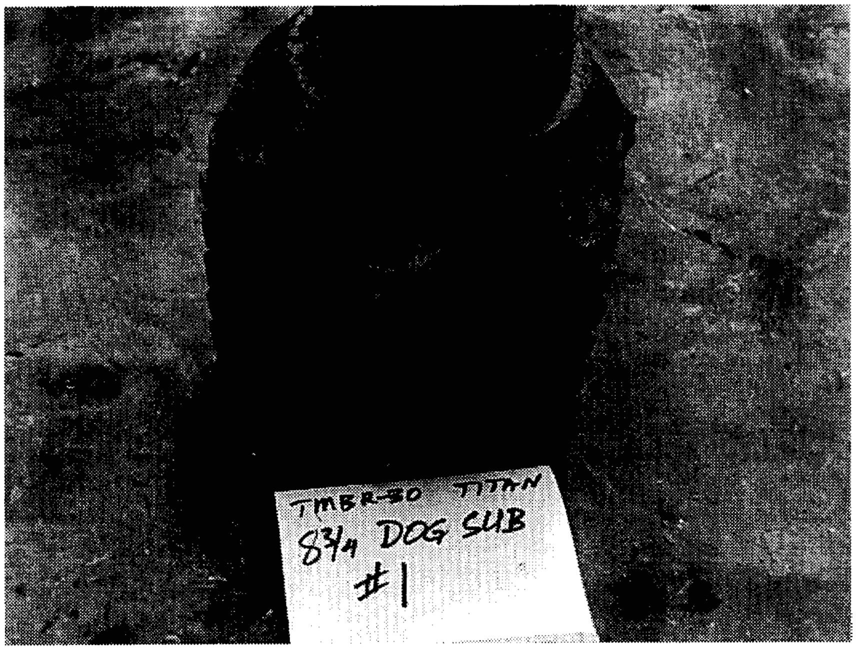

Figure 5

Figure 6

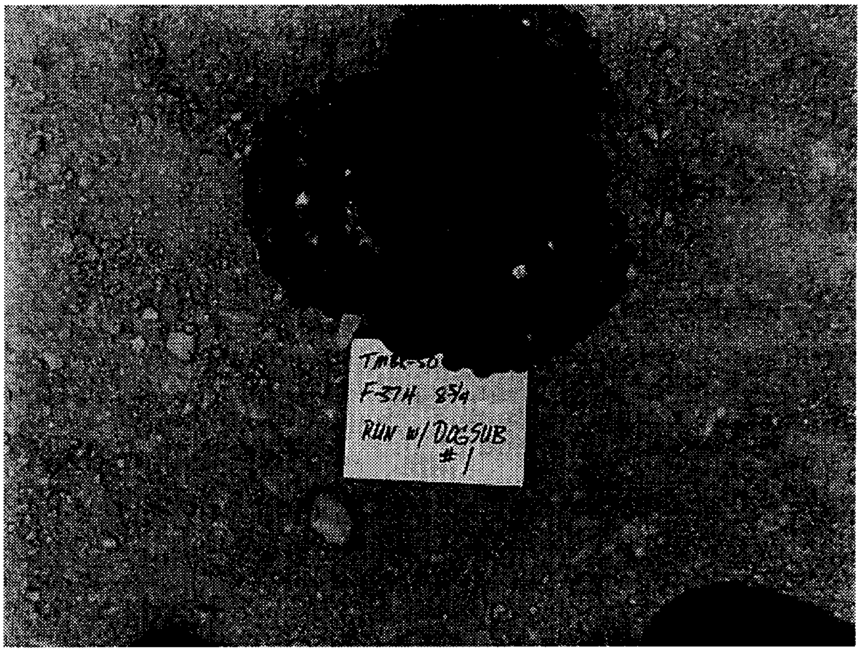

Figure 7

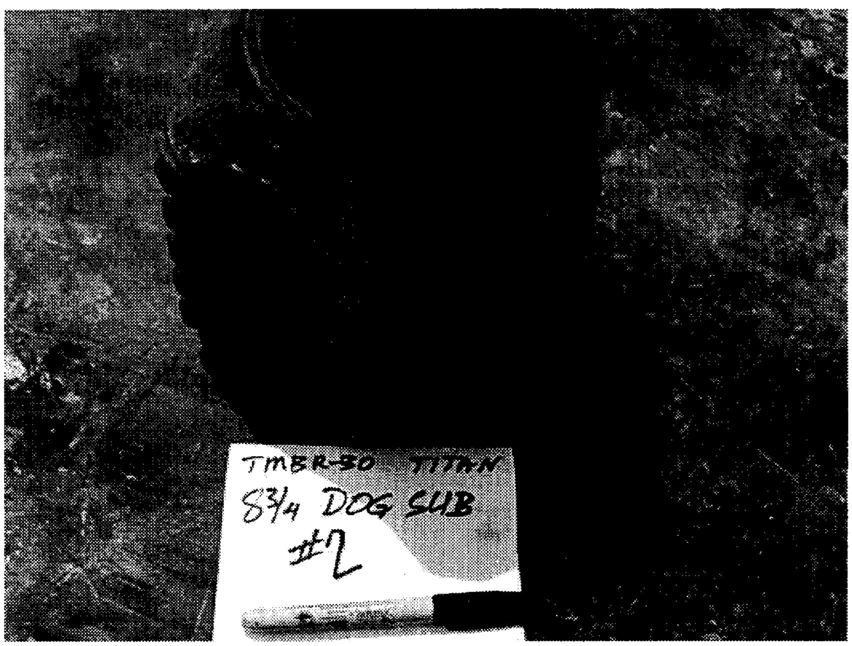

Figure 8

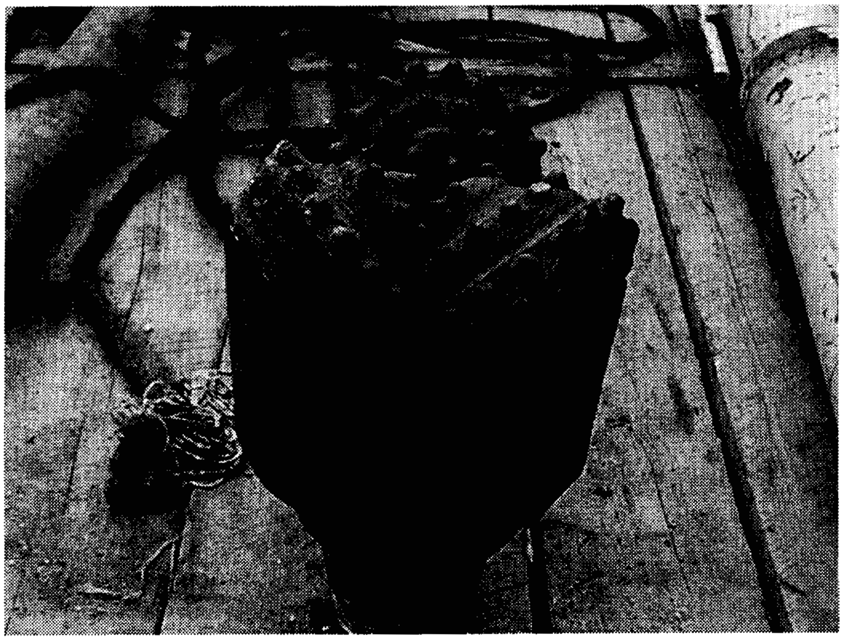

Figure 9