ROCKY MOUNTAIN OILFIELD TESTING CENTER

PROJECT TEST RESULTS

BULL DOG AUGER

SEPTEMBER 15, 1997

FC970006/97DT15

RMOTC Test Report

Rotary Steerable Stabilizer

Smith Drilling and Completions
16740 Hardy Street
P. 0. Box 60068
Houston, Texas, 77205-0068
281-443-3370

Leo Giangiacorno, Acting Project Manager
Rocky Mountain Oilfield Testing Center

December 17, 1997

Introduction

Directional drilling is more expensive than vertical drilling. This is due to the high maintenance cost of downhole motors and MWD systems required to control hole trajectory. In addition, directional holes have lower penetration rates due to the poor hole cleaning with a non-rotating string. Down time is often spent orienting tool face to obtain the desired trajectory after tile weight is placed on the bit and the reactive torque of the motor is absorbed by the drill string. Holes drilled in this manner often have a tortuous profile compared to holes drilled with a rotary system, increasing the torque and drag on the drill string. Increased torque and drag limit the maximum attainable horizontal displacement of the wellbore. All of these inefficiencies have been necessary because of the inability to adequately control trajectory with a rotary system.

An adjustable stabilizer system is already on the market to control 'inclination by varying the diameter of the stabilizer blades during rotary drilling. However this system cannot control azimuth because it operates with gravitational forces in a pendulum assembly. The blades all extend at the same distance, limiting its ability to apply side forces to the bit.

The Rotary Steerable System features independently actuated blades in a floating outer housing that remains static during drill string rotation. These independently controlled blades enable side forces to be placed on the bit behind a near bit stabilizer fulcrum point to control the tool face and change hole azimuth as well as inclination. It also employs "smart" technology to sense rotation and orientation, compare it to the programmed trajectory, and make correctional changes to maintain the desired trajectory.

Description

The Rotary Steerable Stabilizer was developed by 3D Stabilisers, Ltd., and is being marketed by Smith Drilling and Completions for use *in directional drilling and controlling the inclination of nonvertical wells. It is designed to be used as the first string stabilizer. It provides the steerability of a conventional mud motor, while still providing the smooth wellbore profile and higher ROP's of a rotary system.

The stabilizer consists of a rotating inner mandrel and an outer static housing with three straight (non-spiral) blades. A bearing and seal system maintain an interior environment protected from the downhole drilling mud environment. The diameter of the blades is controlled with an internal hydraulic system, including a pump and accumulator, to maintain the desired hole trajectory. The blades are controlled independently, enabling directional changes as well as 'inclination changes. The hydraulics, accelerometer, and electronics which control the stabilizer are located in the outer, static housing.

Directional control is achieved by the following procedure:

1. The current blade extensions are read and from that the current hole diameter is calculated.
2. The accelerometer package determines the relationship of the stabilizer blades with respect to gravity.
3. The processor calculates the correct blade extensions required to place the stabilizers centerline at the correct tool face and centerline offset from the wellbore centerline.
4. The stabilizer blades will, if required, be moved to the correct position.

The stabilizer can be programmed at the surface with a notebook computer. It can also be set downhole with a new trajectory at any time by sending a coded set of rotational sequences from surface. It is preprogrammed to retract the blades after drill string rotation is stopped for 20 minutes in preparation for tripping out of the hole.

Test Proposal

Smith proposed to test the rotary steerable stabilizer 'in a Tensleep well. This would provide the opportunity to check the operation of the hydraulic system and the software system. It was proposed to test the tool in a 12 1/4" hole with an "S" shaped profile. The ability of the stabilizer to sense a lack of rotation for 20 minutes and retract the stabilizer blades would also be tested. The onboard memory would gather information relating to the orientation of the blades and store it for retrieval at surface. The success of the test was to be judged by the directional control performance and the blade positioning system performance.

Test Design

The test was included in the drilling plans for Well 26XIO. A 13 3/8" conductor was to be set to 96 ft. The conductor was to be drilled out to 250 ft to prepare for the test. A bottom hole assembly containing the rotary steerable stabilizer was then to be run. This BHA consisted of the 12 1/4" bit, a near bit stabilizer, the 3D stabilizer, a monel collar with sub, non-magnetic stabilizer, monel collar, x-over, and 6 1/4" collars.

The initial drilling run was to be for 15 hours to check out systems. The stabilizer was then to be tripped out of the hole and checked for sampling frequency, tool faces, blade extensions, etc. The assembly was then to be reprogrammed and tripped back into the hole for 25 hours of drilling. This process was to be repeated four times to the top of the Second Wall Creek. Build rates of one to two degrees per hundred feet would be used.

Test Performance

Well 27-I-X-10 (renamed after survey) was spudded on February 22, 1997 following two days of weather and mechanical problems. The 13 3/8" conductor was set at 67 ft KB and cemented to surface. 'Me 12 1/4" starter hole was drilled to 250 ft without problems. Another BHA with an integral bit stabilizer was run to check the condition of the hole and measure inclination. The hole was reamed due to tight conditions. At 218 ft, the inclination was 1.26 degrees. Since the inclinometer is gravity based, an inclination of at least 3 degrees is required to get the rotary steerable stabilizer to work. Drilling proceeded to build angle to 462 ft, where the angle was measured to be 2.87 degrees and the well path was falling short of plan. The assembly was tripped out and the integral bit stabilizer was laid down.

The 3D stabilizer assembly was picked up for the next run. It was desired to turn the well towards the north and build angle. The stabilizer centerline was positioned to achieve maximum dogleg with a turn to the left. Drilling continued to 751 ft. The assembly was tripped out after 16 hours to download the memory and asses the total memory utilization. During the run, 15 to 25 klbs weight was held on the bit at 85 to 90 RPM. During this period, ten MWD surveys were made, showing that the assembly was not able to build angle or change the course of the well.

The tool was inspected on the rig floor after the run. Two of the three stabilizer blades were still extended. They should have retracted after rotation stopped for 20 minutes. The seals on the stabilizer blade housing were still intact and the housing was able to be rotated independently with the aid of a chain tong. The hydraulic pump appeared to be working, but unable to generate any pressure. The system had not lost any fluid.

The downhole memory was downloaded. Approximately 50% of the total system memory had been used in the 16 hours of operation. Useful life of this memory configuration is expected to be 24 to 28 hours. Recorded data 'indicated that the blades had worked when drilling was initiated. It was also indicated that the hole diameter was greater than 12 1/4". The tool had actuated the blades several times while the drill string was being worked. The blades were also actuated when the MWD screen was being changed and when the pumps were being worked on for a 3 hour period. By the time drilling resumed, the hydraulic reservoir had been consumed, and the blades were no longer able to be moved.

All of Smith's tools were laid down, since the tool's hydraulic pump I could not be repaired on location, and the test was suspended.

On April 14, the tool was repaired and the test was resumed. The tool was run for about 12 hours, drilling 400 ft on the first ran. The expected build rate was not seen, so the assembly was pulled to download the tool's memory by computer linkup. The data showed a performance history similar to the previous run, with tool function at the beginning of the run, and failure to make subsequent changes due to a short circuit in the hydraulic system**.**

A surface test was performed with the tool in the rotary table. The hydraulic system appeared to be working during the surface test. Therefore the stabilizer was again run downhole. The tool again failed to perform properly downhole on the second try, with the patterns indicating the same failure as on the first run.

All of Smith's tools were laid down. The pump was returned to Aberdeen for additional work.

Conclusions

1. The performance of the tool was terminally affected by problems in the hydraulic system.

2. Memory capacity and downhole performance monitoring systems appeared to be working properly.