ROCKY MOUNTAIN OILFIELD TESTING CENTER

PROJECT TEST RESULTS

BULL DOG AUGER

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RMOTC TEST REPORT

Bull Dog Auger

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Introduction

As reservoirs become pressure depleted, it becomes difficult to perform work on wells that can no longer support a fluid column. A bailer can be used when the fluid column can no longer reach surface, but it requires a significant fluid column to force fluid up into the bailer. When the reservoir pressure drops to very low levels, the bailer will no longer work. Bull Dog Tool has developed a downhole auger that is capable of removing fill independent of a fluid column in the well. This tool will allow low pressured wells to be cleaned out and restored to production.

A well that has sufficient reservoir pressure to support a fluid column to surface is generally circulated to clean out fill. If the fluid column does not make it to surface, a bailer is used to pump out the fill as it is being drilled. In low pressured formations, air can also be used to circulate out fill. There is currently no other effective way to clean fill out of a well that cannot be bailed. Most times the low pressure wells are abandoned when they accumulate enough fill to slow production rates below the economic limit.

In a such a well, large amounts of fluid can be lost to the low pressured formation during clean out operations, causing formation damage. The damage can be in the form of swelling clays, reductions in relative permeability, or simply taking a long time to produce back and return to maximum oil production rates. In some cases, compressed air has been used in low pressure situations, but this can also force solids into the producing zone, causing additional formation damage. It is also fairly expensive to mobilize and operate the compressors. Low pressured wells generally cannot tolerate formation damage or high cost workovers.

Tool Description

The Bull Dog Auger uses rotation to auger fill material up into wash pipe located above the auger in the work string, without the requirement for hydrostatic pressure. The auger works on the principle of Archimedes screw, which mechanically translates rotation into lift. A diagram of the tool is shown in Figure 1. The outer wall, or barrel, of the tool is held static by frictional forces between the bottom and sides of the hole and the tool created by the weight of the pipe. As weight is released on the auger an internal spring engages a hex drive, which connects the barrel with the internal shaft. As the tool is set on bottom, the hex drive disengages and the auger shaft is extended below the bottom of the barrel.

A flapper valve is located above the auger and below the wash pipe to hold the fill up in the washpipe. A perforated sub is located above the wash pipe to allow any fluid brought in by the auger to circulate back down behind the wash pipe, rather than causing excessive back pressure on the auger. When the auger has loaded the wash pipe to its maximum fill height, the string is tripped out of the hole and cleaned out. The process is then repeated until the fill is sufficiently removed.

Benefits

The Bull Dog Auger will be used by oil and gas producers to clean out wells that have
tool company or workover rig service company.

This tool allows another low cost option to maintain production from an existing well. It is especially applicable to stripper and marginal wells. If fill is identified as a potential problem in a low pressured well, the potential of an auger cleanout should be evaluated. The well's full potential production can be determined by carefully studying its previous production and maintenance history, and the potential revenue from the well can be compared to the cost of removing fill from the well and restoring its productive capacity.

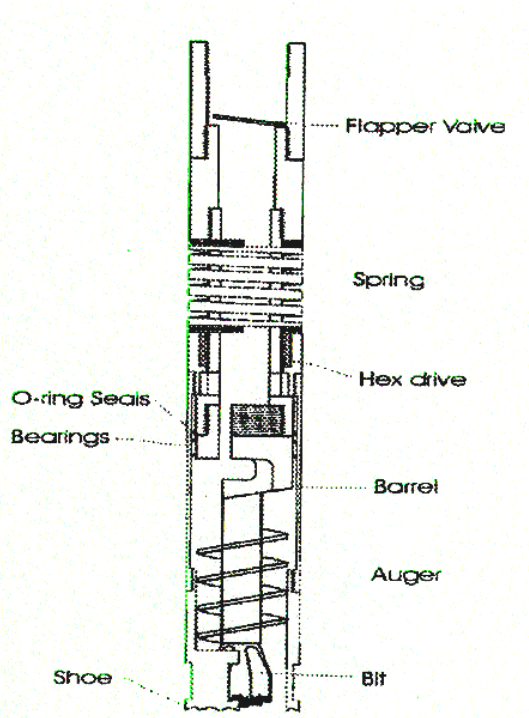

Figure 1. Bull Dog Auger Schematic

Field Test Performance

The Bull Dog Auger was tested in Well 66ShX14 from July 28, 1997 through August 7, 1997. The purpose of the test was to attempt to clean out some of the toughest fill in the oilfield and to observe its performance in this challenging situation. Experience was to be gained with the use of this unconventional tool, allowing optimization of its procedures. If the auger could be made to perform under these conditions, it should be ready for a market that consists mostly of simpler jobs, such as frac sand removal.

The auger was tested with a Kremco workover rig and a Bowen S-2 power swivel. The bottom hole assembly consisted of the 5-3/4" diameter auger, a flapper valve, two joints of 5-1/2" washpipe, a crossover, two 4 1/2" drill collars, another crossover, a perforated sub and the 2-7/8" tubing work string. The details of the BHA are shown in Table 1. Approximately 5,000 lbs of weight was used on the auger, at a rotary speed of approximately 60 RPM.

The drill collars were used to store angular momentum and reduce peak torque loads on the drill string connections. Their small ID causes them to fill quite rapidly, so they are not useful to store fill. The tubing does not store much fill, either. The fill storage area is practically limited to the wash pipe volume. Once the fill level reaches the top of the wash pipe, it quickly rises to the maximum height that the auger is capable of developing, then stops making additional hole. The higher the fill level, the more the fill is compacted, and

the harder it becomes to remove from the auger and wash pipe. The economics of such a clean out are sensitive to the amount of wash pipe run, since it can reduce the number of trips required, however it may also increase the time required to clean out the assembly and run back in the hole.

Table 1. Typical Bottom Hole Assembly

Element	OD, in	Thread down	Thread up	Length,	Cumulative Length, ft
Auger	5.75		5.75 Hydril WP box	9.76	9.76
Wash Pipe #1	5.75	5.75 Hydril WP pin	5.75 Hydril WP box	31.93	41.69
Wash Pipe #2	5.75	5.75 Hydril WP pin	5.75 Hydril WP box	31.47	73.16
Top Sub	5.75	5.75 Hydril WP pin	3 1/2" FH box	2.23	75.39
Xover	4.75	3 1/2" FH pin	3 1/2" IF box	1.75	77.14
Drill Collar #1	4.76	3 1/2" IF pin	3 1/2 IF box	30.79	107.93
Drill Collar #2	4.75	3 1/2" IF pin	3 1/2" IF box	27.68	135.61
Xover	2 7/8	3 1/2" IF pin	2 7/8" EUE 8 rd box	2.00	137.61

The test well produces oil from fractured Niobrara Shale at 2,566 feet. There is 7 inch casing to 1, 184 feet and open hole to 2,651 feet. Fill was tagged at 2,432 feet the first trip in the hole, however, when the auger was run on the next trip, fill was tagged higher, at 1,430 feet. The fill consisted of very fine clay particles with some oil and water mixed with it to give it the consistency of gumbo.

The auger worked through a bridge to 1,442 feet, and went down to 1,665 feet, when some sticking was experienced. On this run, the perforated sub was located one stand above the drill collars. It was learned that the auger can fill the wash pipe very quickly and then the perforated sub above the wash pipe can allow some of the thinner fill slurries to exit the fill pipe and deposit above the drill collars, between the pipe and the hole walls. This situation can potentially cause the BHA to become stuck in the hole. This was remedied by putting the perforated sub immediately on top of the collars, rather than a stand or two above them. Little fill can then exit before the small annulus is filled and the fill is forces higher in the tubing, quickly reaching the maximum height potential of the auger. The auger was surprisingly efficient in bringing well slurried fill up into the wash pipe. It was capable of filling the wash pipe to its maximum capacity in less than an hour.

The auger showed that it was very capable of filling the wash pipe with fill material, and it could do this rather quickly, especially if the fill consistency was somewhat soft. Once the auger had pushed slurry as far up into the wash pipe as it was capable, the assembly ceased making additional hole. Continuation of rotation at this point would heat the fill adjacent to the auger shaft, and bake it dry. This resulted in sticking the auger shaft in the barrel. It then becomes difficult to clean out the auger.

Handling of the auger, wash pipe, and tubing required the use of different size handling tools. Pipe wrenches were used during this test, requiring excessive time to break down, clean out the auger and wash pipe, and reassemble the bottom hole assembly. Two BHA's could be used so that one could be broken down and redressed while the other one is in

the hole. Such use of multiple assemblies that are dressed and partially assembled would improve the efficiency of the operation and make better use of rig time.

The well was off production before this work was done. Following the work, the well was placed on production at 12 BOPD. At the time of this report, production has been sustained for 6 weeks. The cost of this test was approximately $7,500. Production from the well has produced revenues of $9,500 over the six week period, indicating a payout occurred shortly after one month.

The Bull Dog Auger was shown to be an innovative and excellent tool for removing fill from these low pressured well bores. Although it was not directly tested on frac sand, it is expected to be an excellent tool for this application. Other more sticky fill such as the gumbo, or dry fill will require more work, however, even in this tough material, it has proven able to remove it from the well. Due to the different nature of such a tool, a learning curve was experienced in its use. Over the short period of this test, much was learned about its operation. The conditions of the test were very difficult, with open hole, gumbo, and sloughing shales entering the wellbore. As the tool becomes more commonly used in the oilfield, the experience is sure to yield much more effective procedures and applications.

The Next Step

The Bull Dog Auger is now ready for market. A prototype tool was tested at RMOTC in 1996. Extensive redesign following this test resulted in a much improved tool that was tested in 1997. Some improvements will be made in the tools now being built for market. Tool availability will be limited at first until production catches up with demand. Bull Dog Tool intends to build a few tools at a time and gradually introduce them into the marketplace, making improvements as the experience base builds.

The Bull Dog Auger will be available to the end user primarily through rental - tool and workover service companies. These companies will obtain the auger through Bull Dog Tool, Inc on a lease or purchase basis as the tools are built.

The Problem

What problems does this RMOTC-tested product help solve and/or what opportunities does it create for users?

As reservoirs become pressure depleted, it becomes difficult perform work on wells that can no longer support a fluid column. A bailer can be used when the fluid column can no longer reach surface, but it requires enough fluid column to force fluid up into the bailer. When the reservoir pressure drops to very low levels, the bailer will no longer work. Bull Dog Tool has developed a downhole auger that is capable of removing fill independent of a fluid column in the well. This tool will allow low pressured wells to be cleaned out and restored to production.

What was the state of the existing technology before this product was available (or tested)?

A well that has sufficient reservoir pressure to support a fluid column to surface is circulated clean. If the fluid column does not make it to surface, a bailer is used to pump out the fill as it is being drilled. In low pressured formations, air can be used to circulate out fill. There is currently no other effective way to clean fill out of a well that cannot be bailed. Most times the low pressure wells are abandoned when they accumulate enough fill to stop production.

What problems or limitations were associated with previous technologies or practices used to solve this problem?

In a well that cannot support a fluid column to surface, large amounts of fluid can be lost to the low pressured formation, causing formation damage. In some cases, compressed air has been used in low pressure situations, but this can also force solids into the producing zone, causing additional formation damage. It is also fairly expensive to mabilize and run the compressors. Low pressured wells cannot tolerate formation damage or high cost workovers.

The Solution

How does this product help solve the problem or create the opportunities described above?

The Bull Dog Auger uses rotation to auger fill material up into wash pipe located above the auger in the work string, without the requirement for hydrostatic pressure.

What is the technical basis or concept that makes this product work?
The auger works on the principle of Archimedes screw, which mechanically translates rotation into lift. The outer wall of the tool is held static by frictional forces between the hole bottom and walls and the tool created by the weight of the pipe. A perforated sub is located above the wash pipe to allow any fluid brought in by the auger to circulate back down behind the wash pipe, rather than causing back pressure on the auger. When the auger has loaded the wash pipe to its maximum fill height, the string is tripped out of the hole and cleaned out.

The Benefits

What types of persons in our industry would benefit from this RMOTC-tested technology?
The Bull Dog Auger will be used by producers to clean out wells that have been frature-treated, or filled with scale or other solids during production. It may be used as a stand alone treatment to restore production to a well, or as part of a larger workover program. The tool will probably be supplied through a rental tool company or workover rig service company.

What specific measurable benefits can people expect to gain when they use this technology?
This tool allows another low cost option to maintain production from an existing well. The well potential can be determined by its previous history, and the potential revenue from the well can be compared to the cost of removing fill from the well and restoring its productive capacity.

The Field Performance

Explain the results of the RMOTC field test.

The Bull Dog Auger was tested in Well 66ShXI4 from 7/28/97 through 8/7/97 The purpose of the test was to attempt to clean out some of the toughest fill in the oilfield and to observe its performance. Experience was to be gained with the use of the unconventional tool, allowing optimization of its use. The test well produces oil from fractured Niobrara Shale at 2,566 feet. There is 7 inch casing to 1, 184' KB and open hole to 2,65 1'. Fill was tagged at 2,432' the first time in the hole, however, when the auger was run, fill was tagged at 1,430'. The fill consisted of very fine clay particles with some oil and water mixed with it to give it the consistency of gumbo. The auger worked through to 1,442', when some sticking was experienced. It was learned that the auger can fill the wash pipe very quickly and the perforated sub above the wash pipe can allow angered slurry to exit the fill pipe and deposit between the wash pipe and the hole walls. The auger was surprisingly efficient in bringing fill up into the wash pipe. It would fill the wash pipe to its maximum capacity in a few minutes, and then heat up and dry out the fill in the auger, causing the barrel to stick. It then becomes difficult to clean out the auger.

How was the product tested?

The auger was tested with a workover rig and a power swivel. The bottom hole assembly consisted of the 5-1/2" diameter auger, a flapper sub, two joints of 5-1/2" washpipe, a crossover, a perforated sub and the 2-7/8" tubing work string. Approximately 5,000 lbs of weight was used on the bit, at a rotary speed of approximately 60 RPM.

How did it perform?

The auger showed that it was capable of filling the wash pipe with fill, and it could do this rather quickly if the fill consistency was somewhat soft. When the wash pipe was full, the assembly ceased making hole. Continuation of rotation at this point would heat the fill in the auger and bake it drym sticking the auger in the barrel and making it difficult to clean out. Handling of the auger, wash pipe, and tubing required the use of different handling tools. Changing out these tools proved to be time consuming, and a simpler BHA should be considered. The use of multiple assemblies that are dressed and assembled while the alternate string is in the hole would improve the efficiency of the operation.

The well was off production before this work was done. Following the work, the well was placed on production at 12 BOPD. At the time of this report, production has been sustained for 6 weeks.

How can it be applied to other operations?

The Bull Dog Auger is an excellent tool for removing fill, especially frac sand after a hydraulic fracture treatment in low pressure, low fluid level wells. Other more sticky fill such as the gumbo, or dry fill will require more work, however, even in this tough material, it has proven able to remove it from the well.

The Next Step

Is this product ready for the market or is it a prototype or in the development stage?

The Bull Dog Auger is ready for market. A prototype tool was tested at RMOTC. Some improvements will be made for the tools being built for market. Tool availability will be limited at first until production catches up with demand.

What are the testing company's plans for developing this product?

Bull Dog Tool intends to build a few tools at a time and gradually introduce them into the marketplace, making improvements as the experience base builds.

How will it be made available to the industry?

The Bull Dog Auger will be available to the end user through rental tool and workover service companies. These companies will obtain the auger through Bull Dog Tool, Inc on a lease or purchase basis as the tools are built.