Fishing Techniques for Drilling Operations

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Abstract

Fishing is the process of removal of equipment that has become stuck or lost in the wellbore. Its name derives from a period in which a hook attached to a line was lowered into the borehole. The fish, or lost object, is classified as tubular (drill pipe, drill collars, tubing, casing) or miscellaneous (bit cones, small tools, wire line, chain, junk). Industry wide, twenty-five per cent of drilling costs may be attributed to fishing.

Operator error, equipment decline, and failure to clean the hole are the cause of many fishing jobs. Running more mud weight than necessary can cause differential (wall) sticking. When hole conditions permit, differentially stuck pipe may be freed by spotting nitrogen. Worn or improperly shopped tool joints may part while tripping or drilling ahead. Interior corrosion in the body of drill pipe may cause torsion failure.

Fishing equipment for tubular goods includes overshots, baskets, spears taper taps, die collars, mills, washpipe, jar-bumper sub assemblies, surface bumpers, safety joints, bent joints, wall hooks, circulating subs, and cutters. Additional tools for fishing junk are the magnet and the junk shot.

The cardinal rule of fishing is “Know when to quit.” Close cooperation between geology, engineering, and accounting is necessary to a successful fishing job. Sidetracking or abandonment may be cheaper than prolonged fishing operations. A fish on the bank is a liability when its recovery cost more money than leaving it in the borehole.

Introduction

The need to remove lost equipment from the borehole is as old as the drilling industry. In the days of the spring-pole cable tool, drillers used a hook connected by hemp rope to the pole in order to recover drilling tools inadvertently left in the well bore. The physical and operational similarity to the angler’s art christened the process of lost tool recovery “fishing” (Moore 1955). The Prud’homme family plantation near Bermuda, Louisiana, displays in its museum a set of rotary drilling equipment, including fishing tools, used to dig three water wells in the year 1823. A French engineer designed this equipment, and an African slave built it (Brantly 1961). Both rotation and reciprocation were powered by a fifteen-man prime mover. Most fishing tools were designed for cable-tool drilling and for production operations, then adapted for rotary drilling. Fishing tools have been necessary ever since man began drilling holes in the earth.

It has been said that fishing operations account for 25% of drilling costs worldwide (Short 1995). Since fishing is a non-routine procedure, all personnel connected with a given job are more likely to commit operational error. Study of the fishing art before such study is needed can be beneficial for engineering, geological, operational, and accounting staff.

Types and Sources of Fish

Anything that goes in the hole can be left there and anything with an outside diameter less than that of the hole can be dropped in it. Fish may be classified as tubular (drill pipe, drill collars, casing, logging tools, test tools, and tubing) or miscellaneous (wire line, hand tools, tong parts, slip segments, bit cones, chains, and junk). After a fishing job begins, any and all fishing tools put in the hole may themselves have to be removed by fishing.

According to Short, the most common fish are bit cones. Cones are run off for several reasons: poor solids control, poor hydraulics, improper bit choice, operator error such as dropping or pinching, manufacturing defects, excessive time on bottom, inordinately abrasive lithology, and unsuspected junk on bottom.

Proper attention can prevent all of these situations except for manufacturing defects and abrasive lithology. The hole must be uncovered in order for hand tools to be lost down it. This can most easily happen when nippling up, followed by the time when a complex bottom hole assembly passes through the rotary table during tripping. At this time, the rotating head packing, if present, must be removed, and some reamers and stabilizers will not even pass through a common stripping rubber. Loose tong and slip dies should have been repaired prior to tripping and especial care should be taken with hand tools during this period. Drilling ahead with an old stripping rubber on top of the flow nipple can help prevent this type of loss during connections.

Drill collars are lost through worn and poorly shopped boxes and pins, through over and under make-up torque, through harmonic stresses, and through failure to use a wedding band (collar clamp). Make-up torque failures can be avoided by the use of a gauge, wear can be found by inspection, collar clamp loss stopped by adequate supervision, and harmonic stress can be minimized by proper rotary speed. Poor shopping is a matter that is harder to deal with, and it seems to be on the increase.

Drill pipe generally experiences torsion failure, although it can be pulled in two, particularly during heavy jarring. It is commonly thought that most drill pipe twists off in the handling area, i.e. three feet below the box, because of slip damage. This is not true. Slip cuts are continually being polished in the borehole and cannot become the source of corrosion failure. Inside the pipe, however, the innermost layer of drilling fluid is stationary and provides an optimum environment for the formation of corrosion pits that mature into holes in the pipe. When a hole in the pipe is found within two or three feet of the box or pin, it is almost a sure sign of internal corrosion failure.

Stuck pipe is caused by failure to clean the hole, by keyseats, and by differential (wall) sticking. Proper mud and proper hydraulics will keep the hole clean. Keyseats may be alleviated by the use of a keyseat wiper at the top of the bottom hole assembly. Overbalance is the cause of differential sticking; running a balanced mud system will address this problem.

Logging and other wireline tools may become stuck in the hole at any time. Parted wireline is very difficult to fish, as it has a natural tendency to ball up; only relatively short sections can be recovered per fishing run. For this reason all rope sockets should be crippled. This means that the weakest spot in the wireline needs to be at the point of attachment to the tool, so that the line may be pulled free of a stuck tool and recovered by its winch. Wireline tools should be fitted with a fishing neck so that they may be recovered with a normal fishing assembly. A sonde containing a radioactive source, an unusually expensive tool, or a tool lost in a washout or large diameter hole should not be treated in this manner. The wireline should be left attached to the tool and recovery attempted by the cut-and-thread procedure. Although this method is more complex and takes much longer, it is more likely to recover the fish.

Catches

The strongest type of catch is the screw-in connection. This simply is the procedure of screwing back in an upward-looking box with a pin of the same thread, or vice versa. This is the catch used after free drill string is backed off during stuck pipe recovery. The second strongest catch is the outside grab. Overshots and die collars are tools used in this technique. The third strongest catch is the inside catch; spears and taper taps are inside catch devices. The outside catch is stronger than the inside catch for the same reason that upset tubing has a greater setting depth than non-upset tubing of the same size, i.e. greater thread or slip surface area. When the annulus decreases to a point beyond which an outside catch tool would have insufficient cross sectional material to do the job, an inside catch must be used. The fourth type of grab is the swallow. This catch is weak, but it is often very useful. The junk basket and poor boy basket have done good service when applied correctly.

Well Control

Outside catch assemblies and washover assemblies must be run in and out of the hole at modest speeds (Walker 1984). Surge and swab pressures generated by these larger than normal tools could bring about lost circulation and/or blowout. Remember that well control always takes precedence over other operations, including fishing.

Fishing for Bit Cones, Tong Dies, and Small Tools

When the bit is on the bank and the small junk is in the hole, several choices present themselves. If the hole is mudded up and a fishing magnet is immediately available, go directly back to bottom and try to catch the fish. If not mudded up, or if a magnet is not on location, run a used bit below two junk subs and attempt to bust and wash by the junk. If no hole can be made, mud up and call for a junk basket. When it arrives or mud up is complete, round trip placing the junk basket on bottom. Cut hole equivalent to the length of the junk basket and withdraw from the hole. The junk basket is similar to a core barrel and will retain the fish and core by means of retainer springs. If the fish is recovered, drill ahead. If not, run a used bit and attempt to drill and wash by them. If no hole can be made, mill the junk with a concave mill. The concavity will center the cones or tools and bust them up. The two junk subs should remain in the string until the iron has been accounted for. Especial care should be taken to remove all metal junk from the hole before a diamond or P.D.C. bit is run.

Fishing for a "Twist Off"

Examine the bottom of the recovered drill string and determine as far as possible the condition of the top of the fish. Dress the appropriate circulating, releasing overshot with the mill guide, slips or grapples, and pack-off rubber necessary to catch the fish. Use a cut lip guide. Prepare a fishing assembly with jars and bumper sub and run it in to within one joint of the fish. Circulate and condition the hole; if not mudded up do so at this time. Never attempt to catch the fish without mud in the hole. Going back to bottom without mudding up is a risk best taken by young men working in boom times. After the hole is in good shape, lower the drill string near the top of the fish and circulate for a few minutes only. Stop circulating and attempt to engage the fish. Go down until some weight is taken off the blocks, then pick up slightly. Turn the pipe a little so that the cut lip of the overshot skirt either kicks the overshot over the fish or off to the side. Take more weight off the blocks to seat the slips or grapple, then pick up to see if the fish is caught. If not, repeat the procedure, being very gentle in order not to rough up the top of the fish. It may be necessary to mill the burrs off the top of the fish so that the overshot will slip on. This is accomplished with the mill guide with which the tool was dressed.

If the weight indicator indicates that the fish is caught, attempt to establish circulation. If circulation is possible, condition the hole once more before chaining out of the hole. Should the pipe not move, begin working and jarring operations, remembering that applying string weight and rotating to the right will release all standard overshots.

If the fish cannot be caught, several things could be wrong. Oversized hole or washout may have allowed the top of the fish to fall against the borehole wall. A bent joint or knuckle joint and wall hook assembly may have to be run in order to centralize the fish top. A lead impression block may have to be run to determine the condition of a damaged fish top. The damaged top may have to be milled in a separate operation. If the fish will not move after jarring and working, it will have to be treated as stuck pipe.

Freeing Stuck Pipe

The three main causes of stuck pipe are cuttings and cavings, keyseats, and differential sticking. Cuttings and cavings build up in the annulus when mud and hydraulics fail to keep the hole clean. Poor design, deteriorating mud systems, pump failure, holes in the pipe, or many other conditions may give the same result. The drill string may not move up or down, and circulation may be restricted or absent.

Keyseat sticking generally occurs while the pipe is moving upward. The top of the drill collars, the uppermost stabilizer, and the bit are the most likely parts of the drill string to hang up in the keyseat, or slot, cut into the dogleg by the downhole assembly. Complete circulation is nearly always present during keyseat sticking, and the pipe is more likely to have freer movement downward than upward.

Wall stuck pipe generally displays full circulation, but both up and down pipe movement are restricted equally. This type of sticking nearly always occurs in the bottom hole assembly. It comes about when the drill string has been stationary for a time. It is common when drilling highly deviated holes and when keyseated. Differential pressure across the drill collars forces strong contact between the drill collars and the side of the borehole. The mud properties conducive to wall sticking are overbalance and high water loss.

When the drill string sticks, work it in the direction opposite to which it was moving when it became stuck. Work it for an extended time, jarring if drilling jars are in the bottom hole assembly and above the free point; do not immediately call for the fishing equipment. Decide what type of sticking is involved, and use stretch table to determine where the free point. If the drill pipe is worn to less than nominal weight, stretch tables may not be accurate. It should be possible to determine if the free point is moving up the hole. If this is the case, it is time to do something else. Continue working the pipe while decisions are being made.

If the drill string is stuck above a depth of 600 m, it may be possible to move it downward with surface jars, although the author has had little success with surface jars unless the pipe is stuck above 400 m. If it is known that differential sticking has occurred, spot a lighter fluid, like diesel to lower the pressure differential, always considering up hole well control requirements. Spotting nitrogen can be instantly effective, but surface pipe and surface equipment must be more than adequate to control any possible kick. Nitrogen is hard on mud, so sufficient volume of good mud to displace the volume ruined by the nitrogen should be available. If carbonate cuttings stick the drill string, spotting acid may help; remembering that a considerable amount of acid gas will be produced.

Either of two devices may be chosen to obtain information about the downhole situation. The freepoint device records applied torque and tension by mechanical-electrical means. It can only determine the uppermost depth at which the pipe is free to move. The stuck-pipe log is a type of sonic log. The information it obtains is similar to that of a simple cement bond log. It is able to survey the stuck pipe all the way to bottom. It is of course more expensive than the freepoint device. The author recommends that the stuck pipe log be run first. The fishing job can be planned most effectively with complete information. After backing off once wireline operations wireline operations may be prevented by millings or cuttings within the fish.

The back-off tool consists of a rope socket, sinker bar, collar locator, and pigtail or rod. Primer cord is looped on the pigtail or rod. This assembly is known as a string shot. Torque is worked down to the tool joint selected for separation. Holding tension and torque, position the string shot in this tool joint and ignite the charge. Withdraw the back-off tool and then trip out of the hole. Always back off at least one joint above the tool joint. Use area logs to avoid backing off in known washout zones. Also, never back off within two hundred feet of the last casing shoe; this interval is known to be prone to washout. Rather than back off in this section, back off inside the casing.

If the stuck-pipe log shows only a small section of the fish to be stuck, a simple fishing assembly may be run rather than a wash-over assembly. Below the drill pipe run four to six drill collars (one for each inch of jar diameter), fishing jars, bumper sub, one drill collar, back-off sub, and tool to catch the fish. This assembly can be used to wash over with washpipe and rotary shoe substituted for the catch tool. A spear may be used between the back-off sub and the washpipe if it is thought possible to wash over to the bit and remove the fish on the same pass. Do not run over 150 m of washpipe; washing over is a dangerous procedure, although less so in open than in cased hole. Washing over in cased hole is one of the most risky of fishing operations.

Fishing jobs, which require successive back off and catch operations may find the path of the wireline tool to be blocked. This is particularly common after milling. After an irregular fish top has been dressed with a flat-bottomed mill, it sometimes pays to redress it with a tapered or pilot mill before making a catch tool run. Sometimes small workover tubing is used to drill out the impediment. Coiled tubing units are effective this task, but they are expensive.

Milling

Besides the dressing of fish tops, mills are used to grind up junk, to cut casing windows, to ream out casing, to cut fishing necks, and to mill up tubulars that cannot be fished, such as drill pipe cemented in the hole. Clustered tungsten carbide, such as Klustrite, is used to face mills. Larger particles are used for milling larger objects. Mills dressed with finer particles may be run fairly fast, but the author is uncomfortable with milling speeds in excess of one hundred revolutions per minute. Too much weight will knock the larger particles off of the mill face. High speed and high weight certainly do not invariably yield high rate of penetration. One or two magnets should be used in the possum belly and cleaned continuously while milling. Cuttings are known to build up in the stack, which should be inspected and cleaned as needed.

Economics of Fishing

The cardinal rule of fishing is “Know when to quit.” Operations, geology, engineering, and accounting personnel comprise the drilling team. All must work together in order to decide how long to continue fishing. Daily fishing costs must be examined rigorously and compared to the total cost of abandoning the fish and skidding or sidetracking. Several recent papers deal with this situation.

Petrobras has conducted an assessment of 3000 fishing jobs in its five major areas of operation (Cunha and D’Almeida 1996). An elegant risk analysis model was utilized; eighty distinct probability density functions were generated. Implementation of this risk analysis method is through software.

BP Exploration has examined 209 stuck pipe incidents and developed a method meant to provide the most cost effective fishing time (Schofield et al 1992). Their method utilizes only four variables plugged into an algebraic formula to determine a cost ratio. This cost ratio applied to a proprietary chart yields an optimum fishing time.

A Mitchell Energy engineer presented an operational plan for parted and stuck drill string (Adkins 1993). A set of risk factors for fishing and sidetracking were presented in tables along with practical estimated costs. This study showed that for the area of operation and depth of well involved, immediate sidetracking would save money.

Short (1995) gives a recommendation for fishing jobs in wells planned for 1500 m or above. When the cost of fishing is equal to one-half the cost of drilling to the same point again, the rig should be skidded in the case of oil wells or sidetracked in the case of gas wells.

Fishermen

"Always choose the fisherman with the most gray hairs" (Cearley 1998). Experiential knowledge has always been the key to successful fishing. Jim Short is one of the few expert fishermen to have recorded his experiences in a textbook. It is interesting to note that retiring fishing personnel at Petrobras have been required to record their case histories and opinions as part of a fishing expert system (D'Almeida et al 1997).

Operators may feel that they are at the mercy of fishing tool companies. One solution to this problem is the concept of cash incentive. A generous bonus offered to both the fishing tool company and to the on-site fisherman for banking the fish within a set time period might be an idea whose time has come. Enlightened self-interest is a concept proven by history.

Conclusion

Fishing is a complex and risky operation. All members of the drilling team must contribute to its success. The engineer must approve the selection of tools and procedures, keeping in mind well control and safety. The geologist should supply offset logs for the purpose of determining washout areas, and he should prepare an evaluation of the well's progress as a prospect. If sufficient reserves have been drilled above the fish, it may be cheaper to plug back. If it is evident that the well is running low, it may be advisable to abandon it before throwing good money after bad. Accounting must keep day to day costs and projections with which to advise the operations personnel who ultimately must choose what course to follow.

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