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TURBO-REAMER FOR WELL BORE ENLARGEMENT AND HEALING KEY-SEAT PROBLEMS IN A DIRECTIONAL OR HORIZONTAL OIL/GAS WELL WHERE DRILL STRING ROTATION IS NOT POSSIBLE

Ritesh Soni

B-Tech final year, Petroleum Engineering, University College of Engineering, Rajasthan Technical University, Kota, Rajasthan, India

Abstract: **The global economy is dependent on many factors in which oil/gas prices are one of the most dominating factors. The cost of drilling an oil/gas well plays a vital role in the assessment of final oil/gas prices. Any drilling difficulties and drilling time delays increases the drilling cost. In present, stuck pipe is the main culprit for drilling time delays and generating drilling problems. When formation rock swells, the inside dia of the well bore decreases and the larger parts of the drill strings get stuck. Same drastic problem occurs when a key-seat is generated while drilling a deviated well. The only solution to overcome this problem is to ream out the well bore section of small dia i.e. well bore enlargement. This short note presents a new technique for this well bore enlargement by a reamer that is basically a turbo machine operated by drilling fluid flow. This technique eliminates the limitations of conventional reamers, those does not give required results when well bore is deviated. In conventional solution the drill string is not permitted to rotate in a deviated well bore but this new proposed technique is able to provide a solution in a deviated well bore too. So this proposed technique is a time savior, money savior and easy to establish.**

1. BACKGROUND

1.1. Key-Seated Holes And Their Conventional Method Of Removal

During oil/gas well drilling operations the lower portion of the drill string is in compression and the upper portion in tension. A neutral point necessarily exists where the drill pipe in compression changes to a state of tension. The location of the neutral point varies with the weight carried on the bit and the weight of the drill assembly and drill pipe. Generally this neutral points are kept bellow the top of the dill collar. By doing this the entire drill pipe above the drill collar is in tension. If, in drilling a well, the well bore deviates from the vertical and on continued drilling this portion of the hole is opposite drill pipe in tension, a definite pulling action is exerted by the drill pipe on the wall of the hole. This pulling action, combined with the circulation of drilling fluid, broaching action of the tool joints and rotation of the drill pipe, results in a tendency for the drill pipe to drill itself into the wall of the hole. Making a section like a key-hole shape and this is called key-seat problem.

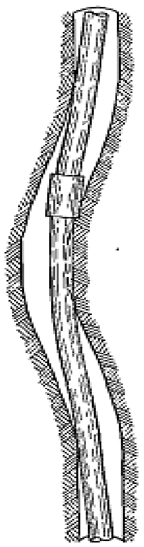
Fig. 1 shows diagrammatically a section of crooked hole, illustrating the pulling action of the pipe and the broaching action of the tool joints on the wall of the hole. The extent of the crook is exaggerated for illustrative purposes.

Fig. 2 shows the position of the pipe after the key seat has been formed. Shales and soft formations afford conditions suitable for key seating, but the action has been known to take place in comparatively hard formations. Extreme cases of key seating have been observed in which the drill pipe was stuck outside the periphery of the drilled hole. As the size of the key seat is large enough to accommodate the tool joints, any trouble experienced is generally due to the "hanging" of the bit or drill collar.

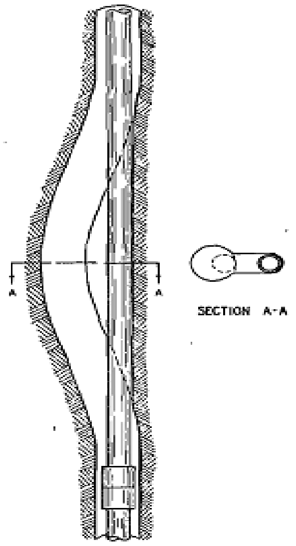
Fig. 3 illustrates how drill pipe is stuck by pulling drill collars into a key-seated hole. If it becomes apparent that a key seat is forming, it is good practice to keep it reamed to the diameter of the drilled hole. The usual procedure is to run a reamer into the drill string, located at a point above the key seat, when the bit is at the bottom of the hole. Blade reamers are used for this purpose in soft formations, but it is necessary to use roller reamers in harder formations.

Fig. 4 shows the action of the reamer enlarging the key-seated hole to the diameter of the drilled hole. It is important that the reamer be started above the key seat in order to prevent the formation of a shoulder.

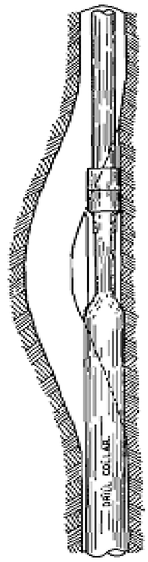
The torque is provided to the drill string at the surface and drill string also rotate reamer blades with itself. The process become unfavorable when the well bore is deviated and drilling is being done by a PDM/ Turbodrill or by any fluid flow operated BHA in which drill string cannot be rotated.



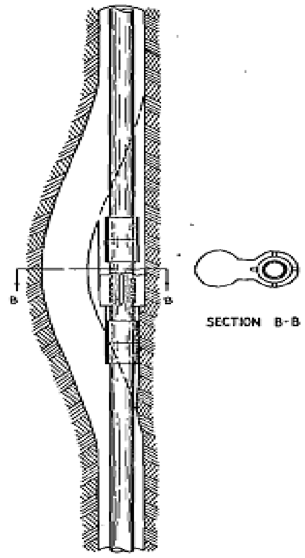
Illustrating Key-Seating Effect on Crooked Hole.
FIG. 1



Position of Pipe after Key Seating.
FIG. 2



Drill Collar Stuck in Key Seat.
FIG. 3



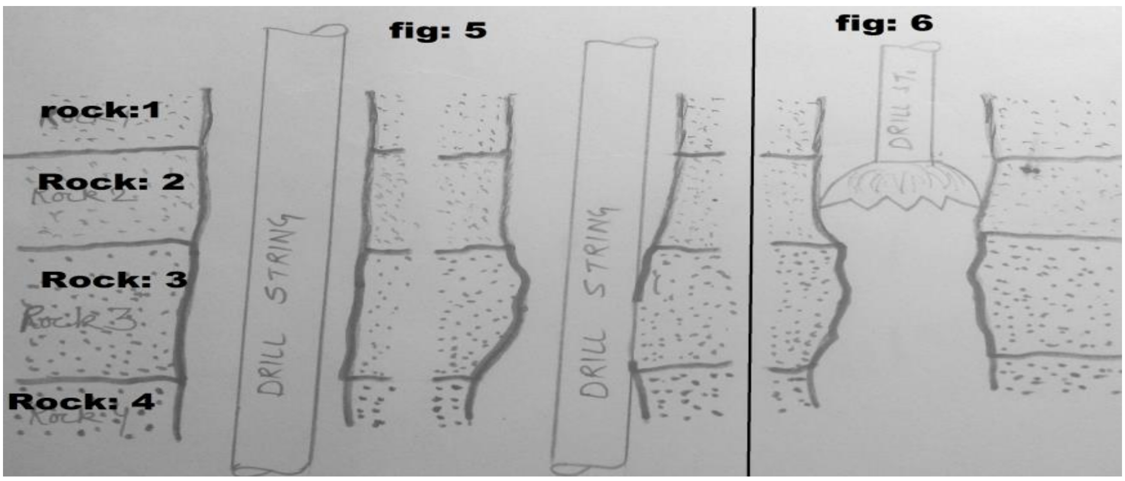
Reamer Action in Enlarging Key Seat.
FIG. 4

1.2. Clay Swelling and Conventional Well Bore Enlargement

Some rocks are reactive with the drilling fluids and they either absorb the water from the mud or react with the mud and they swell. When a rock swell, this phenomena reduces the inner dia of a well bore and enhance the possibility for drill string to be stuck. If there is any sign of clay swelling, drill string is designed with a reamer that rotates with the drill string and enlarge the inner dia of the well bore.

Fig.5 illustrates the clay swelling phenomena and how does it reduces the inner dia of well bore.

Fig.6 illustrates the action of the reamer. It reams out the swelled rock area and enlarge the well bore.



2. PROPOSED TECHNIQUE

2.1. Design

Turbo reamer is a part of BHA and simply can be attached to the drill string by threaded pin-box arrangement. There are some fluid-diverting holes in the vertical base of the turbine. Those holes divert the fluid from the drill sting to the motor section. There are rotor-stator blades that convert the fluid's energy to the rotational energy. There are also some bigger holes in the lower part of vertical base of turbine to divert the fluid from motor section to back in the drill string. The outer body of turbine rotates and cutting materials attached to the outer body cut the rock formation. Some main parts of turbine are as follows.

2.1.1. Motor description: the turbine motor consists of a series of rotors and stators. The stators are curved blades that are fixed on the inside vertical base of the turbine while the rotors are mounted on the inside wall of the turbine's body. The no of stages (pair of stator-rotor) may vary according to the application.

2.1.2. Bearings: three types of bearings have been used. *Thrust bearing*; to resist the axial load exerted on the turbine reamer. Thrust bearing consist of metal disc that slides on the bearing surface of elastomer or synthetic rubber. *Radial bearing*; the purpose of radial bearing is to centralize the rotating components. Elastomer pads on the inside of the bearing supports and a metal sleeve on the vertical base are fitted such that a small clearance exists between them. *Upper/ lower bearings*; the function of the upper and lower bearing is to centralize the upper and lower part of the turbine and to resist the bending stresses exerted on the turbine while drilling.

2.1.3. Cutting surface: cutting surface is attached to the outer wall of the turbine. This surface is made of hard rock cutting materials and while rotating with the turbine body it cuts the rock formation.

2.2. Working

As the drilling fluid is pumped through the turbine, the stators deflect the flow of mud against the rotors, forcing them to turn; ultimately the outer body of turbine is turned. After passing through the stages of the turbine, a small percentage of the flow is diverted though the lower and upper bearings for lubrication. The rest big proportion of the flow is channeled through diverting holes of vertical base of turbine into the main drill string.

The outer body of the turbo-reamer is free to rotate, while the inside section is stationary and connected to the drill string. At the top of the turbo-reamer there is box connection and at the end there is pin connection, so this turbo-reamer can easily be attached to the drill string. The cutting material is strongly attached to the outer rotating body of the turbine. As the rotor blades rotate, the outer body of turbine rotates and attached cutting material also rotates that cut the rock formation and enlarges the well bore and can ream out the key-seat. The profile of the blades has an important effect on the pressure drop through the tool and on turbine's overall performance. All turbine components must be robust to withstand the expected down-hole condition. Some figures are drawn to describe the design and working of this proposed technique.

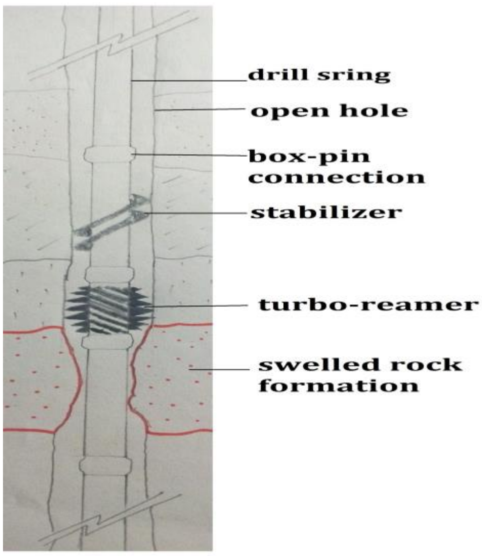


Fig: 7

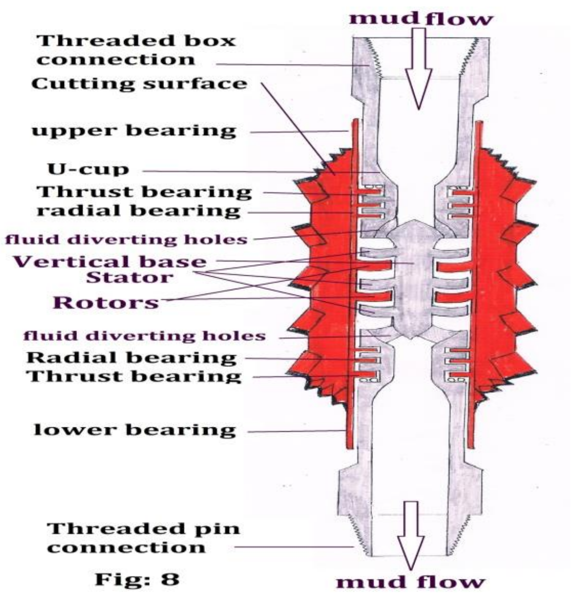


Fig: 8

Fig: 9

Fig: 7 describe how Turbo-reamer can be run as a part of BHA. The swelled rock formation can be cut easily. Fig: 8 showing the vertical cross sectional view of the Turbo-reamer and different parts of Turbo-reamer are shown. Fig: 9 showing one stage of the rotor-stator assembly and how mud flow develops rotational torque.

3. ADVANTAGES OF THIS PROPOSED TECHNIQUE

1. Rotary torque is developed at where ii is actually required so hole can be enlarged without rotating the drill string.
2. Since the drill string does not have to rotate, technique can be used for hole-enlargement and reaming out the key-seat in deviated or horizontal wells too.
3. No need to replace the bit with a reamer so no wastage of time in trip-in trip-out for whole drill string and saving rig time is saving money.
4. Turbo-reamer can be used for both straight and directional wells.
5. It's a part of the BHA so can be run easily with other drill string components.

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