Comparison of Drilling Technologies Between Top Drive and Rotary Table in Geothermal Fields: A Case Study of Olkaria Geothermal Fields

James Kahutu and Victor Atwa

Kenya Electricity Generating Company Limited,
Geothermal Resource Development, Naivasha, Kenya
jkahutu@kengen.co.ke • vicatwa@kengen.co.ke

Keywords

ROP- Rate of Penetration, stands, singles, stuck pipes, top drive, rotary table, drilling efficiency, weight on bit (WOB), tripping

ABSTRACT

Due to accelerated drilling in the geothermal fields, there is need to adopt better drilling technologies to reduce drilling time for the well, drilling down time and increase equipment life time. One of the technologies adopted is the utilization of a top drive compared to a rotary table. A rotary table is a mechanical device on a drilling rig that provides clockwise (as viewed from above) rotational force to the drill string to facilitate the process of drilling a bore while the top drive is a motor that is suspended from the derrick, or mast of the rig to facilitate the rotation of the drill string. The aim of this paper is to compare the drilling efficiency between top drive and rotary table in terms of rate of penetration, ability to manage stuck pipe and general safety during the drilling processes. The paper will use the case study of Olkaria geothermal field whereby both the top drive and rotary table have been used to drill geothermal wells.

1.0 Introduction

Drilling refers to any process of making wellbore by use of different techniques that do not need direct access by man. A well can be made using various drilling techniques including but not limited to cable tool drilling, auger drilling and rotary drilling. This paper will focus on rotary drilling. Rotary drilling is the process of making a well by using a drill bit which is simultaneously forced against a rock formation at the bottom of the hole. The drill bit is attached to hollow steel pipes (drill string) of circular section joined together. The cuttings produced in the process of drilling are transported up to the surface by drilling fluid which can be a combination of mud or water. Rotary drilling is commonly done using either rotary table or a top drive.

Rotary table is a mechanical device located on the drilling floor composed of a fixed base which supports by means of bearing a rotating platform with a central hole. The rotary table provides rotating force to the drill string to facilitate the process of making a well. It also supports the weight of the drill string during drilling operations or during connection of a new drill pipe when the weight cannot be borne by the hook.

Top drive system on the other hand consist of a motor that is suspended from the derrick, which produces the power to rotate the drill string during the drilling process. The top drive is comprised of electric and hydraulic motors, which is connected to the drill string via short section of a pipe known as the quill. The top drive system is preferred in drilling operation over rotary table drilling due to its increased safety and efficiency during operation.

This paper will compare the efficiency between rotary table and top drive with respect to the rate of penetration, ability to manage stuck pipe and general safety during the drilling process.

2.0 Rate of Penetration

Efficiency of any drilling process is dependent largely on the drill bit life and the rate of penetration (Metres/hour). During drilling, the rate of penetration is dependent on the type of formation, weight on the bit (WOB), revolution per minute (RPM) and the bit performance. In order to achieve higher rate of penetration it is important to ensure that the right parameters are maintained during drilling. The correct weight on bit should be maintained to ensure that there is no drag on the drill surface that can result in higher frictional forces which reduces bit life and ultimately the rate of penetration. Proper bit selection also ensures that optimum rate of penetration is achieved; in Geothermal drilling tri-cone bits with tungsten carbide inserts are normally used since they perform better than many other types of bits. The cutting condition of the drill bit is very critical because if the bit teeth are dull all the other factors are overruled. In addition, the circulating fluid plays a very important role in improving the rate of penetration since the drill cuttings need to be removed in order to have a clean surface for the bit to engage the new surface. However, the bearing O-ring seals in these bits are made of rubber that has a temperature limitation of 150-200°C which makes the bearing to seize due to high temperatures during drilling. Proper bit cooling drilling is therefore necessary to increase the bit life and the rate of penetration.

The rate of penetration in any given well is also dependent on the technology in use. When using rotary table for example, bit life in depths greater than 1800m is normally reduced due to bearing failure occasioned by high temperatures especially when tripping in when no fluid is being pumped in hole. The top drive system on the other hand has shown an increase in the rate of penetration in geothermal well drilling since it has overcome the bit heating problem than other conventional drilling techniques because of the continuous water pumping even when running in hole, thereby providing better cooling of the bit. In addition, the top drive uses automatic driller operated pipe elevators, which makes it easier to make connections thereby reducing tripping, surveying, reaming and other non-drilling rig function time and maximize time on bottom making hole (Tesco, 2009). The ability to drill using stands (three drill pipes joined together) while using top drive also reduces connection time as compared to rotary drilling technology where drilling is done using singles (one drill pipe) hence a lot of time is wasted when making connections.

2.1 Case Study

The case study focuses on comparing the efficiency between rotary table and top drive system with respect to the rate of penetration during the drilling process. The two systems have been used in Olkaria Geothermal Field. Three wells have been considered in this case study. Two wells OW-732C & OW-905 were drilled using top drive and OW-732B drilled using rotary table all of them using the same rig. All the three wells have fairly the same formation type.

The findings are tabulated below.

2.1.1 Well OW-732B (Drilled Using Rotary Table by Rig KGN2)

Table 1. ROP for sections of well OW-732 B.

Depth Range	Depth Drilled	Time in hours	ROP in m\hour
740-800	60	10	6.00
800-900	100	24	4.16
900-1000	100	19	5.26
1000-1100	100	19	5.26
1100-1200	100	17	5.88
1200-1300	100	16	6.25
1300-1400	100	26	3.85
1400-1500	100	23	4.35
1500-1600	100	26	3.85
1600-1700	100	21	4.76
1700-1800	100	20	5.00
1800-1900	100	17	5.88
1900-2000	100	15	6.67
2000-2100	100	22	4.55
2100-2200	100	14	7.14
2200-2300	100	18	5.56
2300-2400	100	16	6.25
2400-2500	100	12	8.33
2500-2600	100	21	4.76
2600-2700	100	20	5.00
2700-2800	100	10	10.00
2800-2900	100	12	8.33
2900-3000	100	24	4.16

2.1.2 Well OW-732C (Drilled Using Top Drive by Rig KGN2)

Table 2. ROP for sections of well OW-732 C.

Depth Range	Depth Drilled	Time in hours	ROP in m\hour
750-800	50	12	4.17
800-900	100	24	4.16
900-1000	100	10	10.00
1000-1100	100	10	10.00
1100-1200	100	11	9.09
1200-1300	100	10	10.00
1300-1400	100	12	8.33
1400-1500	100	14	7.14
1500-1600	100	18	5.56
1600-1700	100	12	8.33
1700-1800	100	11	9.09
1800-1900	100	13	7.69
1900-2000	100	12	8.33
2000-2100	100	13	7.69
2100-2200	100	14	7.14
2200-2300	100	18	5.56
2300-2400	100	20	5.00
2400-2500	100	15	6.67
2500-2600	100	13	7.69
2600-2700	100	11	9.09
2700-2800	100	12	8.33
2800-2900	100	14	7.14
2900-3000	100	15	6.67

2.1.3 Well OW-905 (Drilled Using Top Drive by Rig KGN2)

Table 3. ROP for sections of well OW-905.

Depth Range	Depth Drilled	Time in hours	ROP in m\hour
950-1000	50	8	6.25
1000-1100	100	10	10.00
1100-1200	100	18	5.56
1200-1300	100	16	6.25
1300-1400	100	15	6.67
1400-1500	100	11	9.09
1500-1600	100	11	9.09
1600-1700	100	12	8.33
1700-1800	100	11	9.09
1800-1900	100	10	10.00
1900-2000	100	11	9.09
2000-2100	100	9	11.11
2100-2200	100	11	9.09
2200-2300	100	12	8.33
2300-2400	100	13	7.69
2400-2500	100	12	8.33
2500-2600	100	14	7.14
2600-2700	100	15	6.67
2700-2800	100	17	5.88
2800-2900	100	15	6.67
2900-3000	100	24	4.16

2.1.4 Bar Chart Analysis of ROP for the Three Wells

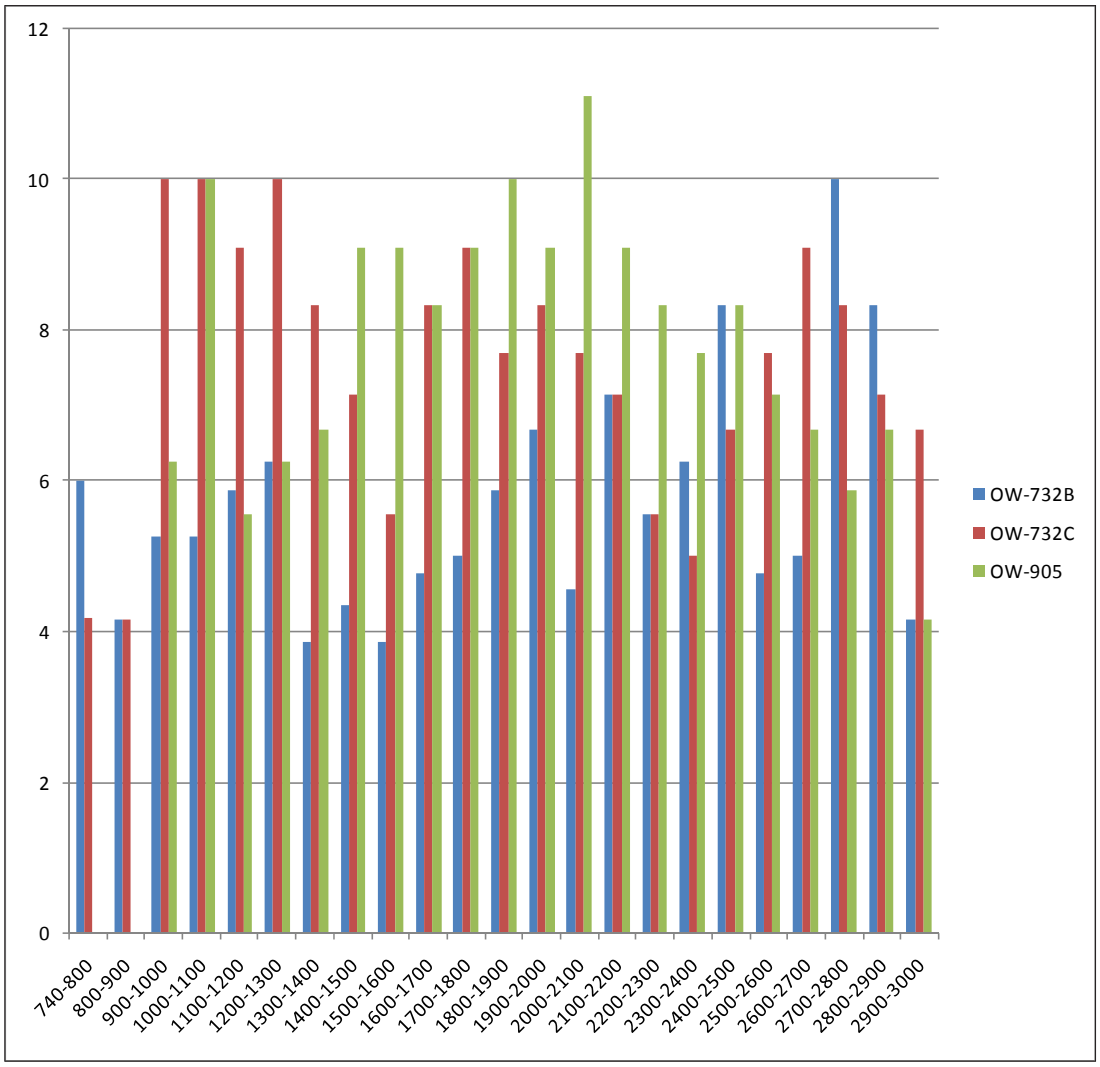


Figure 1. The figure above shows the comparison of ROP for the three wells (OW-732B, OW-732C, and OW-905).

2.1.5 Analysis and Deduction

The data in Figure 1 shows that higher rate of penetration have been achieved by using top drive.

Two wells OW 732B and OW-732C drilled on the same pad using the two technologies show the difference in the rate of penetration when using the two, with the top drive achieving the highest rate of penetration. OW-905 also confirms that higher ROP can be achieved using the top drive.

From the analysis it can be deduced that better ROP can be achieved using the top drive than when using the rotary table with all other factors kept constant.

3.0 Safety Consideration for the Top Drive as Compared to Rotary Table

When drilling using rotary table drilling crew have to operate elevators manually during drilling operations, which normally increases chances of accidents in the rig floor. However, when drilling using top drive the automatic, driller operated pipe elevators eliminate accidents caused by drilling crews operating elevators manually during drilling operations. The top drive also increases safety of the rig equipment by reducing BOP wear and allowing the BOP/rotating head to pack off against round tubular, not a square or hex Kelly used in rotary table drilling. In addition, the top drive make-ups and breaks-out many connections, thereby reducing the hazards of rotary tongs and spinning chain used in rotary table drilling. Well control capability is also enhanced when using the top drive because of the ability to screw into

the string any point in the derrick to circulate drilling fluids continuously while tripping into or out of the hole, which is not possible with rotary table drilling.

4.0 Ability to Manage Stuck Pipe

In the course of drilling operation, the drill string may get stuck while at the bottom due various reasons. This may be due to collapsing formation, dogleg, hole cleaning problems among many other reasons. When this happens, different drilling techniques can be applied to free the stuck drill string. The top drive drilling technology offers an advantage in managing stuck drill string due its ability to back ream. With this, it is possible to achieve full rotation and circulation while tripping out, pull through tight spots and eliminate or reduce the possibility of stuck pipe incidents. Back reaming is very important in that the driller can be able to remedy the situation immediately he realizes the drill string is stuck or about to get stuck. This cannot be achieved when using rotary table which means that other methods to free the stuck drill string have to be employed which increases response time thereby worsening the situation.

Conclusion

Top drive drilling has led to overall improved efficiency in drilling operation. It has led to reduction in drilling downtime caused by picking up and racking back the swivel and Kelly when tripping in or out of hole, drilling of mouse and rat hole, drilling using single drill pipe in the case of rotary table. The top drive has also led to safer drilling operations by eliminating the use of manually operated elevators during operations. In addition the top drive has shown a tremendous increase in ROP in drilling of geothermal wells.

References

Tesco, 2009: Product information site. Tesco Corporation, Ltd, website: http://tescorp.com, 2-9.