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Comparison Between Use of Hammer Bits and Roller Cone Bits on Conventional Rigs, a Case Study of the Menengai Field

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ABSTRACT

Drilling speed of the top section (26" hole to a depth of 80m and $17^1/_2$" from a depth of 80m-400m) has been a challenge in the Menengai geothermal field with low rate of penetration as per intended target. This section is generally hard formation with frequent drilling fluids losses.

Use of the standard roller cone bits on these sections causes a lot of vibrations on the rig leading to frequent breakdowns of the equipment (rotary table and top drive system) and downtime, hence longer drilling periods and high maintenance cost.

Loss of circulations while drilling the top section leads to cement plugs to heal the losses, and use of more loss circulation material (LCM) and drilling mud. This increases the time taken to drill these sections due to wait on cement to cure and overall well costs.

Introduction of the hammer bit on the conventional land rigs in the Menengai geothermal field has proven to have high rate of penetration on the 26" hole and $17^1/_2$" hole section, low/minimum vibrations transmitted to the rig equipment, less drilling fluids used and minimum downtime hence minimum maintenance costs.

1. INTRODUCTION

There are two different types of bits used in the drilling field:

I. Those that break the rock,
II. And those for coring purposes.

In this paper we will focus on two types of bits used to break the rock i.e. roller bits and air hammer bits.

1.1 Roller cone bits

These types of bits consist of three cones turning independently and are assembled on three arms joined together by a welding constituting the body of the tool. Several types of bearings are used (rollers with or without sealing, stages of friction, system of lubrication, etc.). These tools work mainly in compression. Significant improvements have been made to the roller bits such as introduction of Nozzles, tungsten carbide inserts, lubricated & sealed bearings and journal bearing. The purpose of this is to increase the rate of penetration, life span of the tool and thus reduce the cost of drilling. Currently at Menengai Project the roller bits are used for drilling 26'', 17 ½'', 12 ¼'' and 8 ½'' holes with introduction of air hammer bit to increase ROP on the 26'' and 17 ½'' section holes.

Figure 1: Roller bits: tungsten carbide inserts and steel toothed bits.

1.2 Air hammer bits

While drilling with the hammer bit, the bit is situated down the hole in direct contact with the drill bit. The hammer piston strikes the drill bit resulting in an efficient transmission of the impact energy and insignificant power losses with the whole depth. The method is widely used for drilling long holes not only for water wells, shallow gas and oil wells and for geothermal wells. In mining it is also developed for sampling using reverse circulation by a hydraulic or electric motor driven gear box called a rotary head that moves up and down the tower via a feed system generating the pull down required to give sufficient weight on the bit. Flushing of drill the wall of the hole and drill rods is normally done with compressed air.

Figure 2: Hammer drill bits.

2. LITHOLOGY

The lithology of a rock unit is a description of its physical characteristics visible at outcrop, in hand or core samples or with low magnification microscopy, such as colour, texture, grain size, or composition. It may be either a detailed description of these characteristics or be a summary of the gross physical character of a rock.

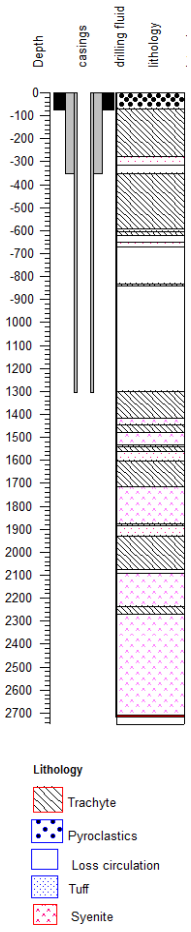

Figure 3: General lithology of the Menengai geothermal field.

In this paper comparison of the lithology of four wells, two drilled by tri cone bit (MW 01 & MW 13) and the other two by a combination of Air hammer bit and Tri cone (MW 21 & MW 10A) was conducted. This was used to show that drilling occurred on almost similar rock surfaces and thus giving a clear comparison between air hammer and tri cone bits on drilling the Top section of the wells (0-80 Metres). The Lithology is shown below.

The Menengai field formation under study (0-300m) consists mainly of Trachyte rocks with pyroclastic lenses. The formation has trachytic lava with thin overlying pyroclastic lenses of around 5 m. The lava is generally fresh and unaltered; it may be blocky and hard to drill. Huge losses of circulation are usually experienced. Due to the blocky nature of the lava in this section, drilling challenges like cave-ins are experienced and therefore cement plugs are done in some of the sections.

3. DATA ANALYSIS

Analysis of the tri cone bit used to drill Well 13 & 1 and hammer bit used in Well 10A & 21. The data is shown below.

Table 1: MW 21 bit analysis

WELL MW-21						
Spud in date	28-11-13					
DAY	**SHIFT**	**BIT TYPE/SIZE**	**METRES DRILLED**	**DRILLING HOURS**	**ROP**	**REMARKS**
1	DAY	REED 26" TRICONE	9.64	8	1.205	
	NIGHT	REED 26" TRICONE	1.8	12	0.150	
2	DAY	REED 26" TRICONE	3.2	5	0.640	
	NIGHT	REED 26" TRICONE	0	0	0.000	WOC
3	DAY	REED 26" TRICONE	0	0	0.000	WOC/DOC
	NIGHT	REED 26" TRICONE	1.91	12	0.159	
4	DAY	REED 26" TRICONE	2.89	12	0.241	
	NIGHT	REED 26" TRICONE	2.7	12	0.225	
5	DAY	REED 26" TRICONE	3.14	9	0.349	
	NIGHT	REED 26" TRICONE	0	0	0.000	C/POOH
6	DAY	REED 26" TRICONE	0	0	0.000	W/H
	NIGHT	**24" AIR HAMMER**	**11.4**	**8**	**1.425**	
7	DAY	**24" AIR HAMMER**	**5.2**	**7**	**0.743**	
	NIGHT	**24" AIR HAMMER**	**1.31**	**6**	**0.218**	
8	DAY	**24" AIR HAMMER**	**0**	**0**	**0.000**	**WOR**
	NIGHT	**24" AIR HAMMER**	**18**	**8**	**2.250**	
9	DAY	**24" AIR HAMMER**	**13.86**	**6**	**2.310**	
	Total		**75.05**	**105**		

BIT	**METERS DRILLED**	**DRILLING HOURS**	**AVG ROP (M/HR)**
REED 26" TRICONE	25.28	70	0.3611
24" AIR HAMMER	49.77	35	1.4220

Table 2: MW 01 bit analysis

WELL MW-01						
Spud in date	12-02-11					
DAY	**SHIFT**	**BIT TYPE/SIZE**	**METRES DRILLED**	**DRILLING HOURS**	**ROP**	**REMARKS**
1	DAY	REED 26" TRICONE	5.67	8	0.709	
	NIGHT	REED 26" TRICONE	4.75	10	0.475	
2	DAY	REED 26" TRICONE	21.95	12	1.829	
	NIGHT	REED 26" TRICONE	9	12	0.750	
3	DAY	REED 26" TRICONE	9.34	12	0.778	
	NIGHT	REED 26" TRICONE	6.4	12	0.533	
4	DAY	REED 26" TRICONE	7.6	11	0.691	
	NIGHT	REED 26" TRICONE	1.56	1	1.560	
	Total		66.27	78	0.8496	

	BIT	**METERS DRILLED**	**DRILLING HOURS**	**AVG ROP (M/HR)**
MW 01	**REED 26" TRICONE**	66.27	78	0.8496
MW 21	**24" AIR HAMMER**	49.77	35	1.4220

4. DATA ANALYSIS

From the data the rate of penetration was improved with the use of the hammer bit. For example, in Well 21 the ROP for Tri cone bit was **0.3611 Metre/hour** and the hammer was **1.422 Metre/hour**. The same is experienced with Well 10A with the Tri cone bit of **0.3760 M/Hr** and Hammer with a ROP of **2.2019 M/Hr**.

This shows that the performance of the hammer bit is better than the tri cone bit with a higher ROP.

Table 3: MW 13 bit analysis

WELL MW-13						
Spud in date	01-01-13					
DAY	**SHIFT**	**BIT TYPE/SIZE**	**METRES DRILLED**	**DRILLING HOURS**	**ROP**	**REMARKS**
1	DAY	REED 26" TRICONE	3.9	4	0.975	
	NIGHT	REED 26" TRICONE	0	0	0.000	WOW
2	DAY	REED 26" TRICONE	0	0	0.000	WOW
	NIGHT	REED 26" TRICONE	0	0	0.000	WOW
3	DAY	REED 26" TRICONE	0	0	0.000	WOW
	NIGHT	REED 26" TRICONE	0	0	0.000	WOW
4	DAY	REED 26" TRICONE	0	0	0.000	WOW
	NIGHT	REED 26" TRICONE	0	0	0.000	WOW
5	DAY	REED 26" TRICONE	0.68	5	0.1360	
	NIGHT	REED 26" TRICONE	3.5	6	0.5833	
6	DAY	REED 26" TRICONE	0.5	1	0.5000	WOC
	NIGHT	REED 26" TRICONE	0	0	0.0000	WOC
7	DAY	REED 26" TRICONE	1.5	5	0.3000	
	NIGHT	REED 26" TRICONE	2	11	0.1818	
8	DAY	REED 26" TRICONE	3.7	12	0.3083	
	NIGHT	REED 26" TRICONE	0.9	6	0.1500	
9	DAY	REED 26" TRICONE	0	0	0.0000	WOR
	NIGHT	REED 26" TRICONE	2.6	7	0.3714	
10	DAY	REED 26" TRICONE	0	0	0.0000	WOR
	NIGHT	REED 26" TRICONE	3.4	11	0.3091	
11	DAY	REED 26" TRICONE	1.43	12	0.1192	
	NIGHT	REED 26" TRICONE	7.8	12	0.6500	
12	DAY	REED 26" TRICONE	4.96	9	0.5511	
	NIGHT	REED 26" TRICONE	3.86	12	0.3217	
13	DAY	REED 26" TRICONE	7.38	12	0.6150	
	NIGHT	REED 26" TRICONE	0.66	2	0.3300	
		Total	48.77	127	0.3840	
		BIT	**METERS DRILLED**	**DRILLING HOURS**	**AVG ROP (M/HR)**	
	MW 13	**REED 26" TRICONE**	48.77	127	0.3840	

Table 4: MW 10A bit analysis

WELL MW-10A						
Spud in date	01-01-13					
DAY	**SHIFT**	**BIT TYPE/SIZE**	**METRES DRILLED**	**DRILLING HOURS**	**ROP**	**REMARKS**
1	DAY	**24" AIR HAMMER**	-	-	-	
	NIGHT	**24" AIR HAMMER**	2.74	7	0.391	
2	DAY	**24" AIR HAMMER**	9.95	2.75	3.618	
	NIGHT	REED 26" TRICONE	0	0	0.000	REAMING
3	DAY	REED 26" TRICONE	0	0	0.000	REAMING
	NIGHT	REED 26" TRICONE	0	0	0.000	WOC
4	DAY	REED 26" TRICONE	0		0.000	WOC
	NIGHT	REED 26" TRICONE	2.6	4	0.650	
5	DAY	REED 26" TRICONE	0	0	0.000	R/WOC
	NIGHT	REED 26" TRICONE	0	0	0.000	WOC
6	DAY	REED 26" TRICONE	0	0	0.000	DOC
	NIGHT	REED 26" TRICONE	3.3	7	0.471	
7	DAY	REED 26" TRICONE	2.96	9	0.329	
	NIGHT	REED 26" TRICONE	3.2	12	0.267	
8	DAY	REED 26" TRICONE	2.74	12	0.228	
	NIGHT	REED 26" TRICONE	3.49	10	0.349	
9	DAY	REED 26" TRICONE	0	0	0.000	WOR/MUD
	NIGHT	REED 26" TRICONE	2.2	7	0.314	
10	DAY	REED 26" TRICONE	6.8	12	0.567	
	NIGHT	REED 26" TRICONE	2.04	5	0.408	
11	DAY	**24" AIR HAMMER**	25	8	3.125	
	NIGHT	**24" AIR HAMMER**	8	3	2.667	
		Total	75.02	98.75		
		BIT	**METERS DRILLED**	**DRILLING HOURS**	**AVG ROP (M/HR)**	
	MW 10A	**REED 26" TRICONE**	29.33	78	0.3760	
	MW 10A	**24" AIR HAMMER**	45.69	20.75	2.2019	

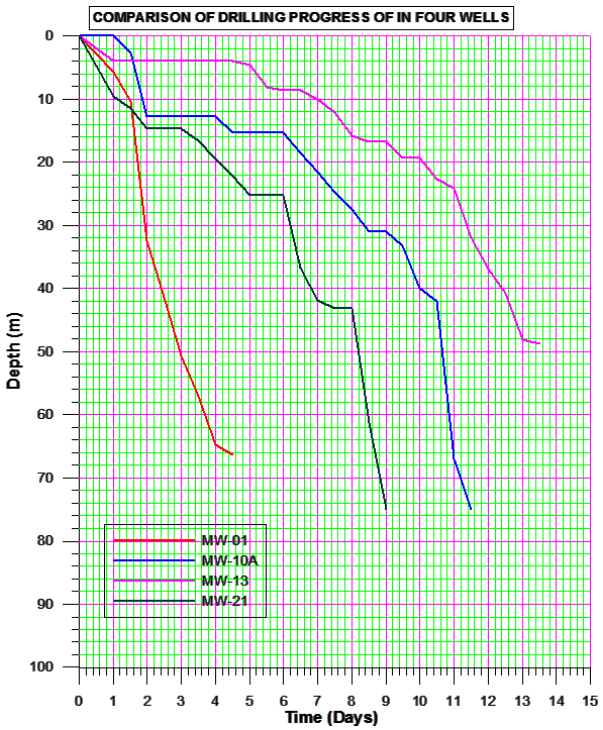

Figure 4: graphical comparison of drilling progress of the four wells.

5. COMPARISON BETWEEN TRI CONE & HAMMER BIT

Table: 5 hammer bit and tri cone bit comparison

S/N	24'' Air hammer bit	26"Tri cone bit
1.	Doesn't require drilling mud (Bentonite)	Requires Drilling Mud
2.	Uses Air drilling compressors minimum of 3 (3450cfm) at a time i.e. more Volume is required than pressure so as to lift the cuttings	Doesn't require air drilling compressors
3.	Air hammer bit is expensive to procure	Less expensive to procure
4.	Higher maintenance cost	No maintenance done
5.	Minimal vibrations transmitted to the rig/Minimal WOR	High vibrations experienced causing breakages to the Top drive, Kelly bushing, rotary table hence Wait on repairs
6.	Minimal Weight on bit used during drilling	Requires higher WOB
7.	Higher ROP	Low ROP

6. CONCLUSION

There are certain limitations imposed on each method of drilling. Hammer drills require the use of compressor in its effective drilling and cleaning the hole. Thus, the cost of drilling is increased as diesel to run the compressors is used (averagely 2000 liters/per day). The tri cone bit is effectively cheaper to buy and operate but has low ROP, hence increasing the days used to drill the well.

We recommend that a 26'' bit hammer be used for the surface hole and 17 1/4" hammer bit for the intermediate hole.

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