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RESEARCH ARTICLE

Comparative analysis of drilling performance of kymera and PDC bits in salt formation

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Abstract

The study compares the drilling performance of Kymera and PDC bits in salt formation using River and Delta State Continental Shelf of Nigeria as a case study. The measurement while drilling (MWD) and the logging while drilling (LWD) methods were used to measure the real time well drilling operation. well formation and drilling statistics. The data obtained from the Ogbaimbiri. Ossiomo. Utorogu and Okporhuftu wells have the penetration rate of 6.2 m/hr. 5.9 m/hr. 12.2 m/hr. 6.3 m/hr for Kymera bit and 4.2 m/hr. 3.4 m/hr. 6.8 m/hr. 3.9 m/hr for PDC bit respectively. The pearson correlation coefficient has a value of r = 0.897. n = 4. p<0.05 and r = 0.784. n = 4. p<0.05 for both kymera and PDC bits. The results established a strong and positive correlation between the penetration rate and distance drilled in each bit. It also shows that the higher the penetration rate the more the distance drilled by each bit. The study concluded that the Kymera bit was more efficient as it was able to penetrate the different formations with a lesser time and at a greater penetration rate.

Keywords: Salt formation, Kymera bit, PDC bit, oil and gas reserve, penetration rate

1.Introduction

From 2012 to 2035 with an average growth of 1.5 % per annum. the primary energy required in the world will be increased by 41 % [1]. This implies that all energy sources have to be increased to meet the energy demand. Perez et al [2] reported decline in oil and gas production which has led to the discovery of pre-salt oil and gas reservoir in order to meet the increasing energy demand. These reservoirs mostly found beyond the continental shelves and under thousands of meters of water [3]. Salts are classified under the evaporite group of sedimentary rocks which includes limestone. dolomite halite. anhydrite and sylvite [4]. Salt is basically water-resistant and are exceptional traps for hydrocarbons. Oil and gas reservoirs are connected with salt structures which are initiate among others in the Gulf of Mexico. North Sea. Iran. Kazakhstan. offshore Brazil and West Africa [5]. Drilling in and through salt was for a long period avoided due to the problems that were faced when drilling salt formations. Engineers were confronted with a foreign operating environment as the formation was covered by thick sheets of salt [6, 7]. When drilling through salt formation. the density of salt becomes lower than the surrounding formation and the salt start to migrate within the covering rocks [8, 9]. As a result of the combined problems of compaction disequilibrium and salt tectonics. complex stress patterns were created in the formations surrounding the salt structures which led to rubble zones and recumbent beds [10, 11, 12]. Therefore. drilling through salt formation requires new and innovative technology to reach the hydrocarbon reservoir [13]. In the recent years, substantial amounts of new innovative drilling technologies have taken place in drilling through salt formation across the world. Gergana [14] studied drilling efficiency and stability comparison between tricone. PDC and kymera drill bits on the Norwegian Continental Shelf. David et al [15] focused on an integrated approach for drilling optimization using advanced drilling optimizer while Shiwei et al [16] conducted an experimental work on the rock-breaking mechanism of using hybrid bit. Pessier and Damschen [17] reported that hybrid bits offer clearly visible advantages in selected roller cone and PDC bit applications. The above researches provided information that were significant for the performance of drill bits in salt formations in many countries but none of them addressed the issue of drilling through salt formations in Nigeria. In order to assess the performance of drill bit in salt formation in Nigeria. this paper evaluates the performance. efficiency and stability of kymera and PDC bits in salt formation for future field drilling optimization using River and Delta State Continental Shelf of Nigeria as a case study

2. Material and Methods

2.1. Description of the Study Area

The selected oil wells are Ogbaimbiri. Ossiomo – 1. Utorogu (Kauf – 2) wells in Rivers State and Okporhuftu (Huha - 3) well in Delta State. The four oil wells are within the sedimentary basin of River and Delta state in the Niger Delta of Nigeria. The areas is located between latitudes 3˚ N and 6˚ N and longitudes 5˚ E and 8˚E in the Gulf of Guinea and in equatorial West Africa [18]. The Ogbaimbiri and Ossiomo -1 wells formations are composed mainly of marine shales with sandy silty beds which occurred as a result of filling of continental slope channels and turbidities while the Utorogu (Kauf – 2) and Okporhuftu (Huha - 3) wells formations are the major Niger Delta petroleum bearing unit. This particular formation comprises mainly of shore face and channel sands with minor shales in the upper part and alteration of sands and shales in equal proportion in the lower part.

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2.2. Method of Data Collection

The geology of the oil wells was studied using microscopes to examine rock fragments (cuttings) from well as they were being test drilled. With the use of seismic survey, the depth of the formations of the wells was determined in accordance with Blackburn et al., [19]. The thickness of the formation influenced the choice of drilling bits. For instance, hard formation requires bigger drilling bits to offset drilling operation. The geological data obtained were recorded and analyzed. The results of the geological data were used to select the sizes of the Kymera and PDC drilling bits to be used for drilling the salt formation. Kymera drilling bit of size 16 inches was used for Ogbaimbiri well while size 12 ¼ inches was used for Ossiomo – 1 well. Utorogu (Kauf – 2) well and Okporhuftu (Haha - 3) well. The drilling of the salt formation was started at the surface depth of 18 m below the water table with a salt tolerant water based mud. Measurement while drilling (MWD) sensor devices were connected to the drill string which sent drilling data to the surface monitor system. From the surface monitor systems. the rate of penetration. depth drilled and formation characteristics of each bit was obtained and recorded. The steerable motor was switched off and tripping out began when the drilling bit penetrated above 300m of salt formation for the Kymera bit and above 150m for the PDC bit.

3. Result and Discussion

3.1. Geological data of the wells

Table 1 shows that the geological data obtained at Ogbaimbiri well were marine shales and silty beds with a formation thickness of about 4,500 m. This influenced the choice of drill bit size 16 inches for the drilling operation because of the rough and hard texture of the geology which may require tripping out and using a smaller bit size if the target depth is not reached within a single run. The geology of the Ossiomo-1 well was shore face and silty bed with the formation thickness of 11,150 m. This also influenced the choice of a 12 ¼ inches drill bit size as the formation was softer than that of Ogbaimbiri well. As a result of this. there was no need for a larger drill bit for the offset drilling operation. The Utorogu (Kauf-2) and the Okporhuftu (Huha-3) wells had similar geological formation characteristics of shore face. minor shale and channel sand characteristics. The formation thickness of the Utorogu (Kauf-2) well was 3,500 m while that of the Okporhuftu (Huha-3) well was 6,000 m. The choice of 12 ¼ inches drill bit size for the two wells still follows the same reason as that of Ossiomo-1 well where the formation was soft and did not require a big drill bit size for an offset drilling operation

Table 1. Geological data of the wells

Location	Geology of the Area	Thickness of Formation (m)
Ogbaimbiri well (Rivers State)	Marine shales, silty beds	4,500
Ossiomo – 1 well (Rivers State)	Shoreface, silty beds	11,150
Utorogu (Kauf-2) well (Rivers State)	Shoreface, minor shale, channel sands	3,500
Okporhuftu (Huha-3) well (Delta State)	Shoreface, minor shale, channel sands	6,000

3.2. Rate of penetration of the two drill bits

Figure 1 shows that the Kymera and the PDC drill bits performance at the Ogbambiri well. The result shows that the Kymera bit drilled a little above 300 m at 6.2 m/hr while the PDC at 4.2 m/hr reaches above 150 m. This shows that Kymera bit was able to penetrate the salt formation at a faster rate than the PDC bit due to its multiple blades and cones which increases cutting and shearing speed. The Kymera bit also proved better as it puts less weight on the drill bit which make it run smoother than the PDC bit which cuts the rock into big sizes and thereby obstructing its ability for a smooth run. This enables Kymera bit to have higher rates of penetration when compared to PDC bit

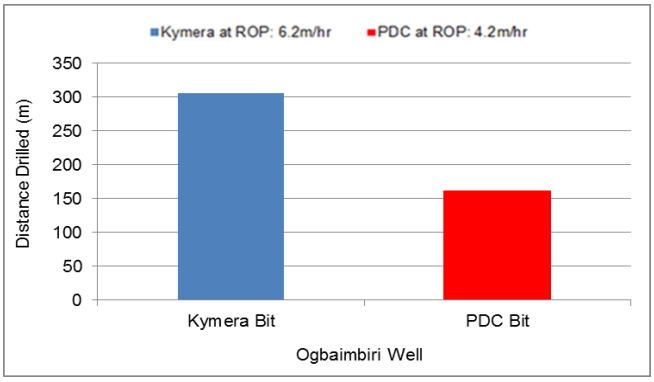

Figure 1. Analysis of distance drilled against the rate of penetration between Kymera and PDC bits at Ogbaimbiri Well

Figure 2 shows that the kymera bit in the Ossiomo-1 well reaches a little bit above 360 m at 5.9 m/hr while the PDC at 3.4 m/hr reaches above 100 m. In this well. the Kymera shows a higher rate of penetration over the PDC. Close range of the distance drilled and rate of penetration between the two bits was expected due to the soft texture of the salt formation of the well and the large cutting radius of the PDC. The cutting and shearing strength of the multiple cones and the blades of the Kymera bit made it to surpass the PDC bit. Therefore, Kymera bit proved its ability over PDC bit through good results of penetration rates. vertical control. distance drilled and stability of the well

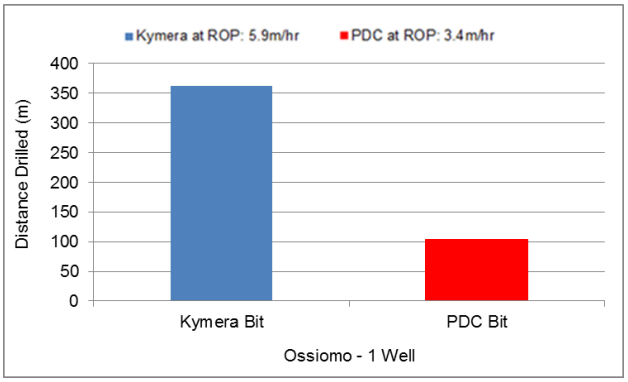

Figure 2. Analysis of Distance drilled against the rate of penetration between the Kymera bit and the PDC bit at Ossiomo-1 Well

Figure 3 shows that the performances of the two drill bits at the Utorogu (Kauf-2) well. The PDC bit at 6.8 m/hr was able to reach a distance of 200 m but when the Kymera was used it outdid the PDC by not only going past the 200 m but reaching a depth of above 400 m. The multiple cones and blades of the Kymera bit aided the increases in the rate of penetration.

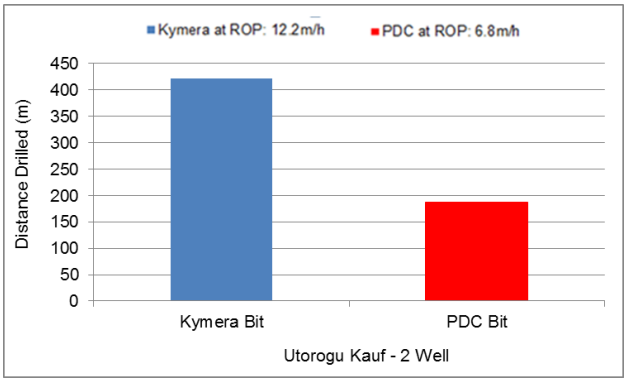

Figure 3. Analysis of Distance drilled against the rate of penetration between the Kymera bit and the PDC bit at Utorogu Kauf -2 Well

At the Okprhuftu well, Figure 4 shows that the Kymera bit drilled a distance of 300 m at the rate of 6.3 m/hr while the PDC bit was expected to perform better due to the formation of the well but it did not as it could only attain a depth above 150 m at 3.9 m/hr. The Kymera bit shows a higher performance rate due to the already mentioned reasons of better and faster shearing property of its multiple cones and blades. Despite the fact that Kymera bit outran the PDC bits. it was discovered that the PDC did not encounter any wear when it was pulled out of the hole. Hence there was no significant difference in stability among the two bit types. This means the two bits were very good while drilling in a shoreface environment.

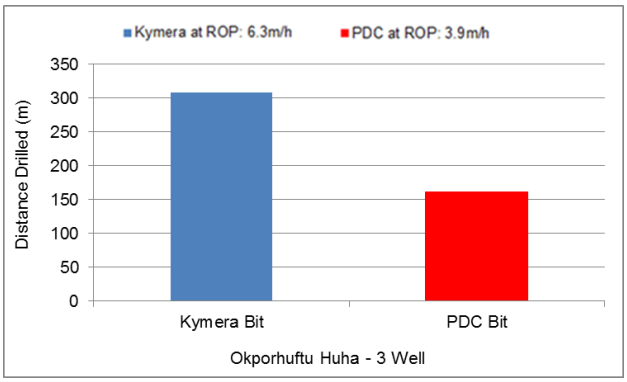

Figure 4. Analysis of Distance drilled against the rate of penetration between the Kymera bit and the PDC bit at Okporhuftu Huha – 3 well

3.2. Correllations analysis of the two drill bits

The relationship between the drilling performance of kymera and PDC drilling bits in salt formation was investigated as well as penetration rate and distance drilled in a single run using pearson correlation coefficient. Tables 2 and 3 shows that there was a strong, positive correlation between the penetration rate and distance drilled in a single run of each bit($r = 0.897$. $n = 4$. $p < 0.05$ for kymera bit and $r = 0.784$. $n = 4$. $p < 0.05$ for PDC bit) with higher penetration rate and the more the distance drilled. the more the increase in a single run for each bit

Table 2. Correlations analysis for Kymera bits

		Rate of penetration Kymera Bit	Distance Drilled Kymera Bit
Rate of penetration Kymera Bit	Pearson Correlation	1	.897
	Sig. (2-tailed)		.103
	N	4	4
Distance Drilled Kymera Bit	Pearson Correlation	.897	1
	Sig. (2-tailed)	.103	
	N	4	4

Table 3. Correlations analysis for PDC bits

		Rate of penetration PDC Bit	Distance Drilled PDC Bit
Rate of penetration PDC Bit	Pearson Correlation	1	.784
	Sig. (2-tailed)		.216
	N	4	4
Distance Drilled PDC Bit	Pearson Correlation	.784	1
	Sig. (2-tailed)	.216	
	N	4	4

4. Conclusion

The field test bit performance show that the Kymera bit has a penetration rate of 6.2 m/hr. 5.9 m/hr. 12.2 m/hr and 6.3 m/hr while the PDC has a penetration rate of 4.2 m/hr. 3.4 m/hr. 6.8 m/hr and 3.9 m/hr respectively. Pearson correlation coefficient shows that there was a strong. positive correlation between the penetration rate and distance drilled in a single run of each bit ($r = 0.897$. $n = 4$. $p < 0.05$ for kymera bit and $r = 0.784$. $n = 4$. $p < 0.05$ for PDC bit). Therefore, Kymera bit was more efficient because it was able to penetrate the different formations with a lesser time and at a greater penetration rate. Also, the Kymera bit proved very efficient by improving bottom hole assembly (BHA) tool reliability while the PDC bit provides a better rock characterization as the cutting size increased. The study recommended that reducing the shock and vibration levels while drilling would improve drilling efficiency and stability of the bottom hole assembly (BHA) tool reliability of the Kymera and PDC bits repectively .

Declaration of Conflict of Interests

The author(s) declare(s) that there is no conflict of interest.

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