International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Technical Performance Analysis of RSS and Mud Motors: A Case Study

Engr. Abdul Qadir Shaikh†, Prof. Dr. Abdul Haque Tunio† and Engr. Mr. Shoaib Riaz‡ Mr. Waseem Arshad†, Engr. Habibullah Sargani†

†Institute of Petroleum and Natural Gas Engineering Mehran University of Engineering and Technology, Jamshoro, Pakistan.
‡Resource Management Specialist, Baker Hughes, Pakistan.
†Technical Manager, Baker Hughes, Oman.

Received 10 Sept 2020, Accepted 12 Nov 2020, Available online 14 Dec 2020, **Vol.10, No.6 (Nov/Dec 2020)**

Abstract

As global demand for oil and gas increases, drilling directional and horizontal wells safely, efficiently and economically requires the best in expertise and technology. The drilling strategy required to reach these targets utilizes one of the several available directional drilling techniques which includes the use of Whipstock, Bent Sub, conventional directional Bottom hole assemblies, Rotary steerable system and positive displacement mud motors. Poor well trajectories become the matter of serious worry in deep and deviated sections of the wells with higher dogleg severity, lower ROP, tolls stucking which causes huge economic loss to the operators. In worst case scenarios the in-adequately drilled directional wells are abandoned. The main objective of this research study will be the intermediate drilling section of the well where the steering of the trajectories like directional drilling trajectories i.e. Slant well, S shaped well and Horizontal wells that will be considered for analysis. This study will analyze the performance of RSS and conventional mud motors, on the basis of rate of Penetration (ROP), drilling depth, and borehole quality.

Keywords: *RSS, PDM, Mud Motors.*

1. Introduction

In this modern era engineering techniques were utilized in every field, in this regard lot of technological advancement were observed specially in directional drilling technology in which most of the directional drilling tools like bent sub, whip-stock, Directional BHA, steerable mud motor and rotary steerable system. Depending upon the performances and usage bent sub, whip-stock, and bottom hole assemblies have little importance because, these tools require tripping in and out during operations. So currently conventional mud motor (PDM) and RSS are frequently used for directional drilling operations still these systems requires extra handling and advancements (Matheus et al., 2012). The incorporated technique is not a very latest technology; it was initially familiarized in nineteenth century(Lentsch *et al.*, 2012). Since this technology initially was developing phase then it was utilized in the directional drilling techniques and results a utmost benefits to drilling industry (Wardana et al., 2019)· Even though this RSS technology provides paramount benefits as compare to conventional mud motors (Hohl *et al.*, 2017), the conventional steerable technology at the present time is often avoided from highly accuracy concern projects as well as from directional drilling projects where directional accuracy is not a major issue (Chen *et al.*, 2016). This new technology were tested and validated with the system of steering advisory system deployed for mud motors which automates the steering related decisions (Zalluhoglu *et al.*, 2019).

The new RSS system with improved pad force, are applied in modern era to push the bit system, for steady DLS at high RPMS (Yan *et al.*, 2018), (Figueredo, 2014). The new RSS technology has not only paramount importance and also it considered as most advance and high delineation technology with high priced daily cost (Wardana et al., 2019). Rotary steerable system provides the real time borehole images measurement and were successful in placing the lateral well paths adequately in the highly steep and complicated beds to have the maximum exposure of the producing reservoirs (Matheus et al., 2012)(Zheng *et al.*, 2019).

Today more and more Directional, ERD and multilateral wells are being drilled in order to access the multiple and geologically complex targets (Nkwocha, 2009), . The drilling strategy required to reach these targets utilizes one of the several available directional drilling techniques which includes the use of conventional directional Bottom hole assemblies, Rotary steerable system, positive displacement mud motors, whip-stocks and geo-steering (Inyang and Whidborne, 2019), (Caicedo *et al.*, 2010). However, all

*Corresponding author's ORCID ID: 0000-0002-4774-060X
https://doi.org/10.14741/ijcet/v.10.6.5

these techniques and tools to make a directional well are not only technically delicate but economically expensive. The in-adequate and hasty selection of any of these techniques often results in the poor well trajectories, which become difficult to run the casing and liners for completing the well (Zafarian et al., 2020). In worst case scenarios the in-adequately drilled directional wells are abandoned, causing a huge economic loss to the operators. RSS technology could be considered as a more efficient because it also enables the access to more complicated bores (Karimi, 2016). The main objective of this study is to analyze the performance of RSS and conventional mud, on the basis of ROP**,** bore quality, and total drilling cost. WellCat™ Software has various design modules the methodology of this study particularly focuses on the Drill module it simulates flow behavior, heat transfer, and also provides the transient analysis of drilling operation.

2. Methodology

The study starts with the literature review regarding the adoption of new RSS technology in directional drilling to reduce the drilling time required to achieve the target depth. The WellCat™ Software was used to analyze the technical parameters like borehole quality, improved ROP. In this case study the three wells A, B, and C having different target depths were used. WellCat™ simulator has various applications, it was used in industry to simulate and modeling of the directional trajectories, Inclination, dogleg severity, builds rate and other trajectory and its related parameters. The methodology adopted in WellCat™ module as follows: Open the Drill module from the toolbar or by opening *Tool*, select product *Drill***.** Then define the used fluids and also each type from Inventories *Fluids*. After that select and define operations from tool bar as: *Drilling Operations* it gives the name to operation in *Operation Name* and then selects particular operation from *Operation Type.* Precede the process with defined operation type as list appears as: *Prior* Drill Operations. Then select another casing string from *Next Casing String*. At this stage you have defined all information if there is need of defining additional information just click *Detail* review and repeat step and define all required operations. Then go to the *Results* section and click on *Calculate* to get the results of any operation from drop list. Then go to the *wellbore* section if you want to review or make changes for *Casing and Tubing Configuration* and save the data by just clicking the *Save* button. And finally review the results generated from *Results* tab for the available options.

3. Results and Discussion

The well A was planned to be drilled in 79 days up to depth of the 3874 meters. The first section of well is up to the depth of the 881 meters. Then next bore section is planned at 3180 meters. The last section is planned to be drilled to the total depth of the well that is 3874 meters. The well B was planned to be drilled in 80 days up to depth of the 4283 meters. The first section of well is up to the depth of the 840 meters. Then next bore section is planned at 3310 meters. The last section is planned to be drilled to the total depth of the well that is 4283 meters. The well C was planned to be drilled in 80 days up to depth of the 4075 meters. The first section of well is up to the depth of the 849 meters. Then next bore section is planned at 3020 meters. The last section is planned to be drilled to the total depth of the well that is 4075 meters.

3.1 Wells Drilled with Conventional PDM

The drilling bore hole to achieve target depth with conventional mud motor for well A were observed about 84 days including completion on other hand well B were drilled to its target depth with completion job in 95 days and the well C to target depth in 99 days. It was observed from response of drilling graph in Fig.1

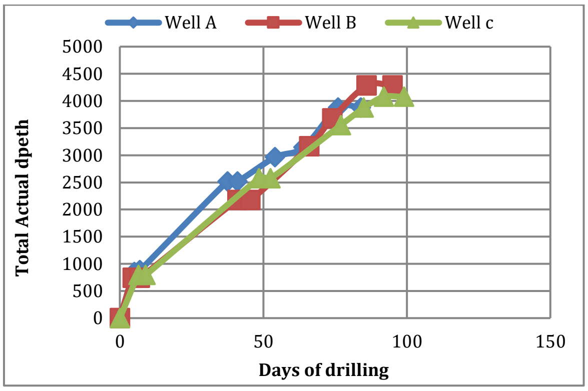

Fig.1 Response of Drilling Well A, B, & C with PDM

3.2 Wells Drilled with RSS

The drilling bore hole to achieve target depth with conventional mud motor for well A were observed about 64 days including completion on other hand well B were drilled to its target depth with completion job in 74 days and the well C to target depth in 78 days. It was observed from response of drilling as shown in Fig.2

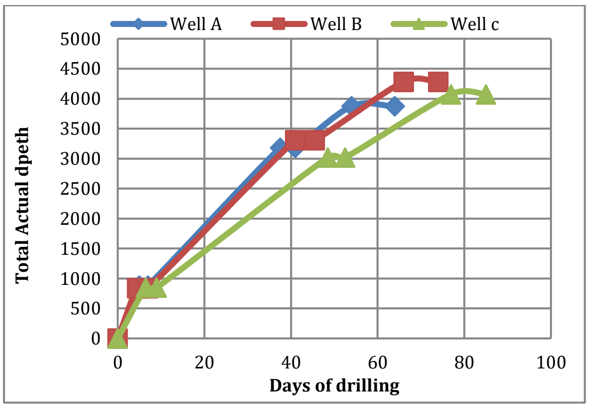

Fig.2 Response of Drilling Well A, B, & C with RSS

3.3 Comparison of RSS & PDM drilled Wells with Well Plan

The adopted BHA of RSS technology has shown suitable drilling performance can be observed in **Fig. 3** that the first section drilled with better ROP with RSS technology taking lesser time to planned period which depicts the cost saving at first section having higher rate of penetration with utilization of RSS technology which reduces the pull outs. However the some days have been saved from planned time in second section of drilling, similarly another few days saved from third section as well. The more days were saved due to the smoothly running of casing, cementing and MWD due to the RSS BHA keeps the well in gauge. The implemented conventional PDM bottom hole assembly has displayed inappropriate drilling performance can be observed in **Fig. 3** the first section drilled with better ROP with conventional PDM but it took more time to planned period which clarifies the extra cost at first section with deployment of conventional mud motors which enhanced the pull outs. Conversely the sometime have been increased from planned time in second section of drilling, likewise another little time consumed in third section of well drilling. The more days were engaged due to the awkwardly implementing service jobs i.e. casing & cementing, and logging jobs.

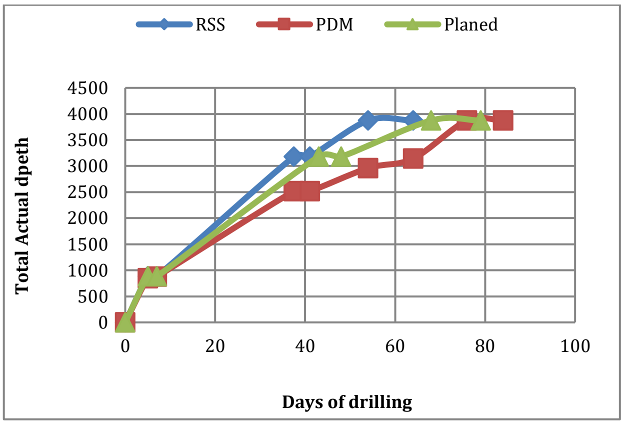

Fig.3 Comparison of drilling Response RSS, PDM, and well planning for Well A

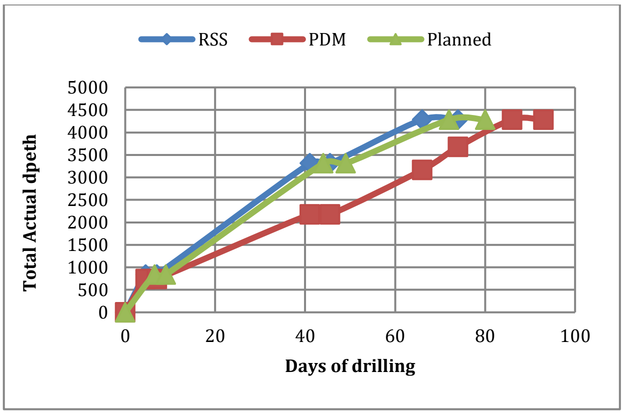

Fig.4 Comparison of drilling Response RSS, PDM, and well planning for Well B

It can be clearly observed from response of well B as shown in **Fig. 4** that the each section took lesser time from planned time for each section, it is due to RSS technology; However the for response of well B with conventional mud motors it seems to be from **Fig. 4** that each section have taken more time than planned that could be the no of pullouts and improper execution of ongoing service jobs i.e. casing & cementing, and logging jobs.

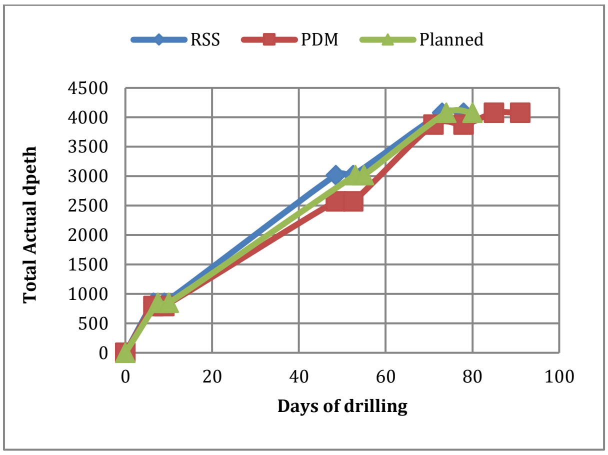

Fig.5 Comparison of drilling Response RSS, PDM, and well planning for Well C

As of above **Fig. 5** it shows that the well C has taken smaller period of drilling at first shallow section, second and third deeps section little more than above two section as compared with planned period of well drilling because of new steerable system; However the for well C with conventional mud motors it seems to be from **Fig. 5** that spent little more days at first and second section than RSS but at the third section it exceeds the planned time that could be the no of extra pull outs and may be any fishing or inadequate execution service jobs.

3.3 Comparison all Wells drilled with RSS

It was observed from the obtained results from software with the usage of RSS technology the most of the drilling time saved as:

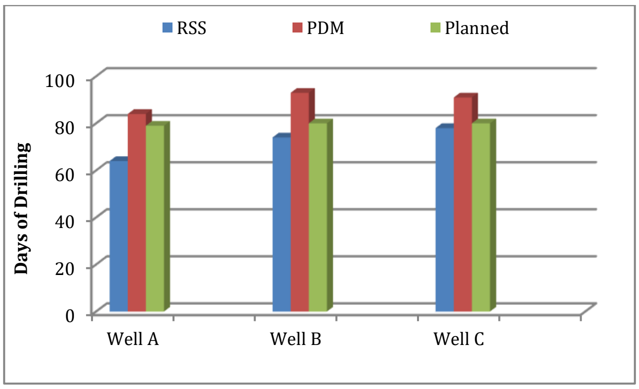

Fig.6 Drilling days for wells A, B, & C with RSS &PDM

well A drilled with RSS it almost saved 15 days of further drilling as compared to conventional mud motors while the well B saved 6 days that seems to be the major advantage of RSS technology in directional drilling, on other hand the well C had save 2 days of drilling as shown in **Fig. 7** that also shows the better ability of RSS in harder and complicated scenarios.

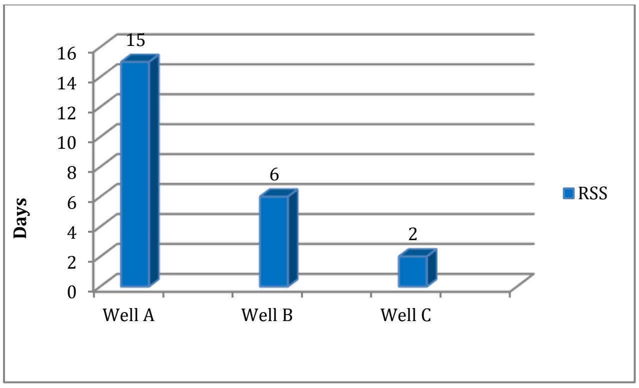

Fig.7 Drilling days saved with adopting RSS

3.4 Comparison all Wells drilled with PDM

It was observed from the obtained results from software with the usage of conventional PDM the extra more of the drilling time required from planned time period as shown in **Fig. 8.** It could be clearly observed from above response graphs well A drilled with conventional PDM it take extra time of 5 days of further drilling from planned and 20 days extra drilling of RSS as compared to RSS technology as shown in **Fig. 6.** While the well B took 13 days extra from planned and 19 days from RSS, that seems to be the major disadvantage of conventional PDM technology in directional drilling as shown in **Fig. 6**, on other hand the well C also taken about 11 more days of drilling from planned and 13 days from new technology of rotary steerable system RSS as shown in **Fig. 6** that also shows the lot of cons of conventional PDM in harder and complicated scenarios.

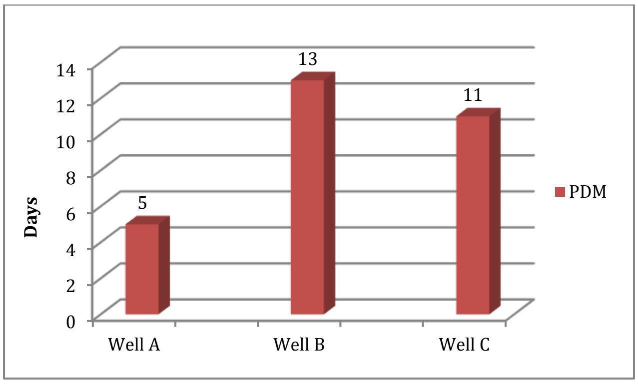

Fig.8 Drilling days extra required with adopting PDM

3.5 Economic analysis

The economic analyses were performed while considering some of the assumption that the average drilling expenditure of RSS and Conventional PDM would be the $30000 per day. The total cost of well is equal to the no of days for drilling multiplied with the average per day cost (Karimi, 2016). and total cost saving would be equal to estimated days saving multiplied with an average per day cost (Karimi, 2016), the results were represented in **Table 1& 2.**

Table 1 Total cost of well drilled with PDM

S.No	Items	PDM System		
		Well A	Well B	Well C
1	Total Target depth, m	3874	4283	4075
2	Drilling Days	84	93	91
3	Total Well Expenses, Millions	$5.46	$6.175	$6.435

Table 2 Total cost of well drilled with RSS Technology

S.No	Items	RSS Technology		
		Well A	Well B	Well C
1	Drilling Days	64	74	78
2	Total Well Expenses, Millions	$4.16	$4.81	$5.525

Table 3 Total cost saved with RSS Technology

Well	Avg: Per day Cost	Estimated days saved with RSS Technology	Cost Saved Using RSS, Millions
A	$65000	5	$0.325
B	$65000	13	$0.845
C	$65000	11	$0.715

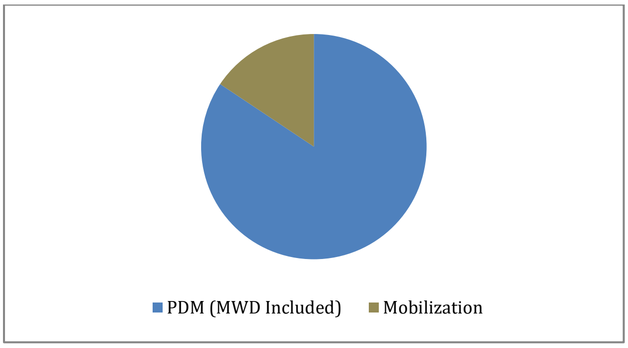

Fig.9 Daily Cost of Conventional PDM, Cost/day

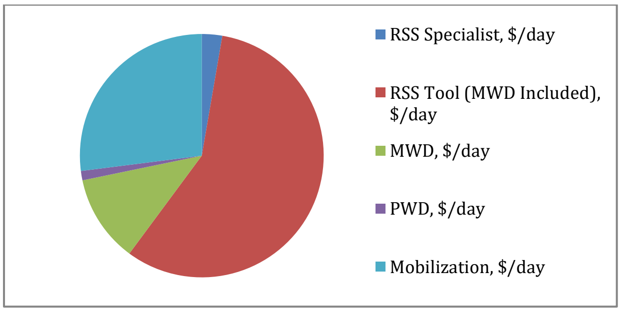

Fig.10 Daily Cost of RSS

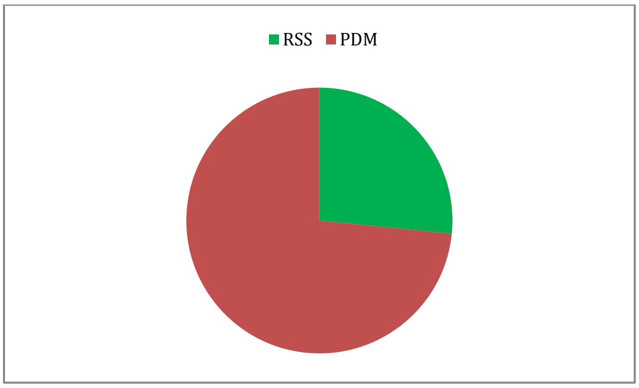

Fig.11 Total Drilling Cost, $

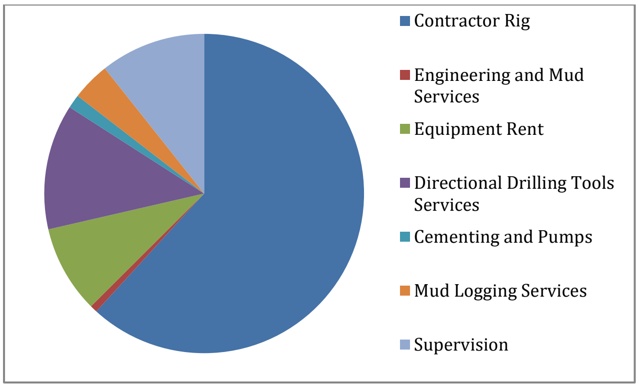

Fig.12 Daily Drilling Cost in $/day

Conclusion

The results of this study follow as:

The implemented BHA of RSS has shown appropriate drilling performance for well A, B & C with superior ROP and lesser time from planned period with smoothly execution of all operations. The implementation of RSS technology on well A, B & C it was observed that the average time saving from well A to C varies. It depends upon the characteristics of different wells and their time of execution and depth of each section. However the for wells A, B & with conventional mud motors it appears that each section have taken more time than planned that could be the no of pullouts and improper execution of ongoing service jobs i.e. casing & cementing, and logging jobs. The results shows that the implementation of new RSS technology in more suitable for directional drilling where different build and drop section are planned.

Though from most of the beliefs that the conventional PDM are the major and important solution for drilling activities, but it wouldn't be the similar case always. Drilling response graphs shows that the new technology RSS has increase the ROP four times in build and drop sections as compare to conventional PDM. Although the RSS technology has cost quarter time greater to conventional PDM, the keeping eye on the total cost while drilling with RSS technology gives the more than two and half times lower than conventional steerable motor due to the significant difference in ROP while building/dropping angle. Moreover, RSS gives smoother borehole and less tortuosity than the conventional PDM. All such facts convey the indirect advantages likewise reducing the casing installation time and also improving the worth of logging data. In the end the utilization of new RSS technology in petroleum fields gives the technical benefits as well as an economic advantage.

References

Caicedo, H. U. *et al.* (2010) 'Geomechanics, ECD Management and RSS to Manage Drilling Challenges in a Mature Field', pp. 1–13. doi: 10.2118/129158-ms.

Chen, X. *et al.* (2016) 'Journal of Natural Gas Science and Engineering Real-time optimization of drilling parameters based on mechanical speci fi c energy for rotating drilling with positive displacement motor in the hard formation', *Journal of Natural Gas Science and Engineering*. Elsevier B.V, 35, pp. 686–694. doi: 10.1016/j.jngse.2016.09.019.

Figueredo, C. (2014) 'Enhanced RSS Technology Pushes Drilling Envelope', *Journal of Petroleum Technology*, 66(03), pp. 32–35. doi: 10.2118/0314-0032-jpt.

Hohl, A. *et al.* (2017) 'Characterization and mitigation of mud motor vibrations', *SPE/IADC Drilling Conference, Proceedings*, 2017-March(March), pp. 1594–1611. doi: 10.2118/184711-ms.

Inyang, I. J. and Whidborne, J. F. (2019) 'Control Engineering Practice Bilinear modelling , control and stability of directional drilling', *Control Engineering Practice*. Elsevier Ltd, 82(October 2018), pp. 161–172. doi: 10.1016/j.conengprac.2018.10.008.

Karimi, G. (2016) 'Rotary Steerable Systems To Reduce The Cost And Increase The Energy Value Of Drilling Directional Wells In Olkaria Geothermal Field', (November), pp. 1–11.

Lentsch, D. *et al.* (2012) 'Overcoming Drilling Challenges With Rotary Steerable Technology in Deep Geothermal Wells in the Molasse Basin of Southern Germany', 36.

Matheus, J., Ignova, M. and Hornblower, P. (2012) 'A Hybrid Approach to Closed-loop Directional Drilling Control using Rotary Steerable Systems'. IFAC, (4020). doi: 10.3182/20120531-2-NO-4020.00008.

Nkwocha, C. O. (2009) 'A practical approach to evaluating directional drilling performance', *Proceedings of the SPE/IADC Middle East Drilling Technology Conference and Exhibition*, (October), pp. 155–172. doi: 10.2118/125322-ms.

Wardana, R. S., Andoni, B. and Pertamina, U. (2019) 'Performance Comparison Analysis Between Rss And', VIII(3), pp. 113–117.

Yan, Z. *et al.* (2018) 'Design of a continuous wave mud pulse generator for data transmission by fl uid pressure fl uctuation', 59(November 2017), pp. 28–36. doi: 10.1016/j.flowmeasinst.2017.11.008.

Zafarian, H., Ameri, M. and Vaghasloo, Y. A. (2020) 'Jo ur na l P re of', *Journal of Petroleum Science and Engineering*. Elsevier B.V., p. 107668. doi: 10.1016/j.petrol.2020.107668.

Zalluhoglu, U. *et al.* (2019) 'Steering advisory system for mud motors', *SPE/IADC Drilling Conference, Proceedings*, 2019-March(March), pp. 5–7. doi: 10.2118/194077-ms.

Zheng, M. J. *et al.* (2019) 'RSS with near-bit GR imaging assist accurate steer drilling in shale gas project in Sichuan: A fit-for-purpose solutions for shale gas drilling case study', *International Petroleum Technology Conference 2019, IPTC 2019*. doi: 10.2523/19464-ms.