

## PERFORMANCE COMPARISON ANALYSIS BETWEEN RSS AND CONVENTIONAL MUD MOTOR IN MAVVAR FIELD

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### ABSTRACT

Rotary Steerable System (RSS) has transformed the directional drilling industry by producing smoother borehole, reducing torque and drag and enhancing the Rate Of Penetration (ROP). Despite the advantages of using RSS, the conventional steerable motor is still widely used in deviated well due to its lower daily cost. Therefore, to optimize the performance and the cost of the drilling operation, it is critical to analyze when the RSS outweighs the conventional mud motor. This paper analyzes the performance between Rotary Steerable System and Conventional Steerable Motor, based on these following parameters: Rate of Penetration (ROP), overall drilling cost, borehole quality and lost in hole cost. This empirical study uses literature study and quantitative data analysis from several wells in Mavvar Field in compliment. The result shows that the Rotary Steerable System (RSS) provides better performance and more efficient in cost.

**Keywords:** *directional drilling, rotary steerable system, the conventional steerable motor*

### INTRODUCTION

There are several tools can be used in drilling directional wells such as whipstock, bent sub, directional Bottom Hole Assemblies (BHA), conventional steerable motor and Rotary Steerable System (RSS). Bent sub, whipstock, and directional BHA are not so practical, because trip out and trip in is required in the operation of these tools. Nowadays, conventional steerable motor and RSS are more common in directional drilling operations.

The conventional steerable motor has been widely used for directional drilling before the invention of RSS until now. In drilling operation that has a broad target and high accuracy is not the main issue, the conventional steerable motor can be used as a reliable tool in directional drilling operations. The conventional steerable motor is often chosen as an alternative to using RSS just because the daily cost is lower than RSS.

RSS is not a brand-new technology. This technology was introduced in the '90s. Since then, this technology keeps developing and has transformed the directional drilling industry. From the experiences, drilling using RSS produced smoother boreholes and better hole cleaning than using the conventional steerable motor (Grini, et al., 2001). RSS also gives another benefit such as making drilling with a more sophisticated target or 3D trajectory possible (Ruszka, 2003). Although RSS offers a lot of benefit than the conventional steerable motor, this technology is often avoided in directional drilling projects where directional drilling accuracy is not the main issue. RSS is considered as the high-profile technology due to its pricey daily cost.

To optimize the drilling operation in performance and economical manner, it is critical to analyze and select when to use RSS over the conventional steerable motor. Justifying when to use RSS over conventional steerable motor cannot be done by only considering the tool's daily cost. Performance comparison analysis should be conducted to be able to choose the right technology to be used. Parameter such as Rate of Penetration (ROP), total drilling cost, lost in hole cost and borehole quality should be considered. This comparison analysis will be depending on the specification of the well design and drilling program.

### CONVENTIONAL STEERABLE MOTOR

The conventional steerable motor is a mud motor equipped with bent housing (figure 1). This bent housing allows for the deflection of the wellbore. The bent housing of conventional steerable motor is the important factor that affects build rate in deviating the well trajectory. It is designed with a certain angle from the centerline of the motor called bent angle. This angle led to side force on the drill bit. The bent angle in PDM can be adjusted as needed.

There are two steering mode in drilling using the conventional steerable motor, rotating and sliding (figure 2). The rotating mode is drilling with drill string rotation. The rotating mode is used for drilling vertical or tangent section, where inclination changes is not expected. In sliding mode, drill string rotation is prohibited. Rotary motion only occurs in the drilling bit. The sliding mode is used in deflecting the wellbore. Deflection in the wellbore is due to bent housing in steerable mud motor. The

Directional Driller has to make calculation according to the length of slide and the length of rotating to get the desired build rate.

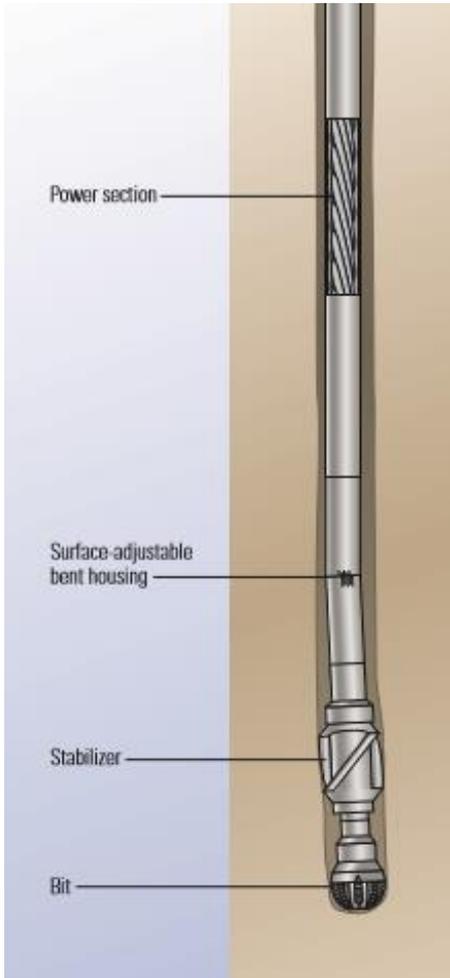


Figure 1. Conventional mud motor (Felczak, et al., 2011/2013)

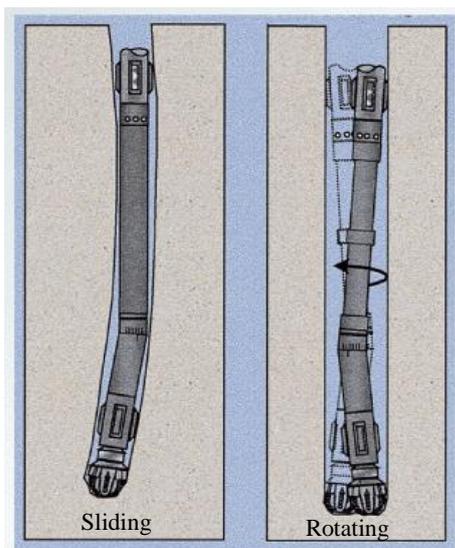


Figure 2. Sliding vs Rotating (Warren, 2019)

### ROTARY STEERABLE SYSTEM (RSS)

The steering mechanism in Rotary Steerable System allows the entire drill string to rotate while deviating the wellbore. This mechanism is allowed due to multiple pads mounted on the body of the RSS (figure 3). These pads can be extended and push the wellbore, causing the bit force to push to another direction. This bit force makes deviation on the wellbore and provides more accurate directional drilling. Extraction and retraction of the pads are conducted by diverting the flow of drilling mud through the controller valve.

RSS technology enables drill string to rotate throughout the drilling process. This continuous rotation of the drill string provides accurate directional drilling and consistent hole cleaning.

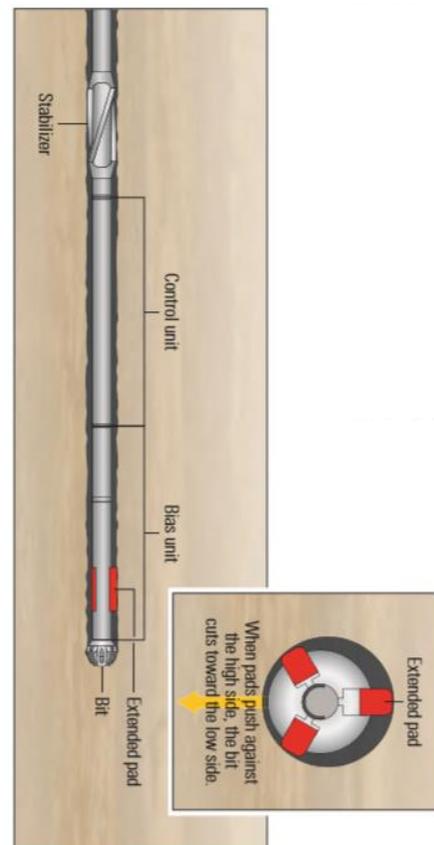


Figure 3. Rotary Steerable System (Felczak, et al., 2011/2013)

### COMPARISON ANALYSIS RATE OF PENETRATION

The conventional steerable motor uses sliding mode in building or dropping wellbore angle. This sliding mode not only affects the hole cleaning but also bit rotation and weight transferred to the bit (Lentsch, et al., 2012). Bit rotation is reduced by the absence of the drill string rotation. Friction between drill string and wellbore also increase in sliding mode. These friction forces reduce the weight transfer to the bit. Reduction of bit rotation speed

and the weight transfer to the bit reduce Rate of Penetration.

RSS enables drill string rotation while deviating the wellbore. The difference in this steering mechanism makes RSS drills faster than the conventional mud motor while building or dropping well trajectory angle.

Table 1 shows a comparison of ROP between RSS and conventional steerable motor. ROP of RSS was not much different from the conventional steerable motor in tangent section. But in build/drop section ROP of RSS was higher 4 times than ROP of the conventional mud motor. This huge difference was caused by sliding action in the conventional steerable system as explained previously.

**Table 1.**

*ROP Comparison Between RSS and Conventional Steerable Motor*

Drilling Section	RSS (m/hr)	Conventional Steerable Motor (m/hr)
Build/Drop Section	21	5
Tangent Section	44	40

**ROP DEPENDANT COST**

Even though RSS provides faster ROP in the drilling operation, it is not always chosen as a directional drilling tool due to its high price. Table 2 and 3 depict the daily cost of using RSS system 5 times higher than conventional steering mud motor. Using RSS will increase the daily cost from \$ 5,022 to \$ 27,020. But it is not correct to say that the conventional steering motor will produce greater cost efficiency. An overall cost of the drilling operation should be calculated.

**Table 2.**

*Daily Cost of RSS*

Description	Price/day
Personel (DD, RSS Specialist)	\$ 1,000
RSS TOOL (MWD Included)	\$ 21,260
MWD	\$ 4,300
PWD	\$ 460
Mobilization	\$ 10,000
<b>Total Cost</b>	<b>\$ 27,020</b>

**Table 3.**

*Daily Cost of Conventional mud motor*

Description	Price/day
Conventional Steerable Mud Motor (MWD included)	\$ 5,022.00
Mobilization	\$ 930.00
<b>Total Cost</b>	<b>\$ 5,022.00</b>

Comparison analysis of total drilling cost between using RSS and conventional mud motor should be considered. Total cost per day includes the cost of the drilling rig, drilling mud services, mud logging services, equipment rental, directional drilling services, mud logging services, standby charge, and personnel cost. Table 4 shows the total daily cost for parameter mention above.

**Table 4.**

*Daily Cost*

DESCRIPTION	DAILY COST
CONTRACT RIG	\$ 30,795
MUD CHEMICALS & ENGINEERING SERV.	\$ 363
EQUIPMENT RENTAL	\$ 4,426
DIRECTIONAL DRILLING SERVICES	\$ 6,327
CEMENT CEMENTING & PUMP FEES .	\$ 688
MUD LOGGING SERVICES	\$ 1,925
SUPERVISION	\$ 5,318
<b>Total</b>	<b>\$ 49,841</b>

With ROP data from the previous well that used RSS and conventional steerable motor, we can calculate drilling time and cost estimation and analyze economic comparison between those two. The well that selected for this economic comparison is deviated well with trajectory S type and Target Depth (TD) 3477 m. The section to be considered for comparison is only 12 ¼” section since this is the deviated part of the well. The maximum inclination is 15.67 degree. Projected total drilling days using both technologies can be seen in table 5.

**Table 5.**

*Total Drilling Time*

Description	Length (m)	RSS (days)	Conventional Steerable Motor (days)
Build Section	242	0.56	2.02
Tangent Section	1146	1.08	3.7
Drop RSS	325	0.53	2.71
<b>Total Drilling Time</b>		<b>2.18</b>	<b>8.43</b>

Drilling using the conventional steerable motor produce slower ROP due to the intermittent sliding interval as shown in table 5. It will take 2.18 days to reach TD using RSS. It means RSS drills 4 times faster than the conventional steerable motor for this project.

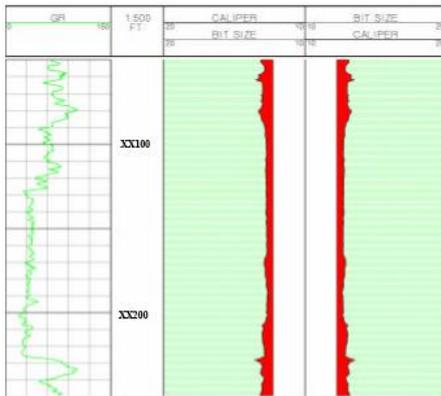
Table 6 describes the economic comparison between the total cost of using RSS and steerable mud motor. From the total cost, it is clearly seen that using RSS for this drilling project can save the company \$ 294,922. Even though the daily cost of RSS is 5 times higher than conventional mud motor, RSS gives the most economical solution to the drilling project.

**Table 6.**  
*Total Drilling Cost*

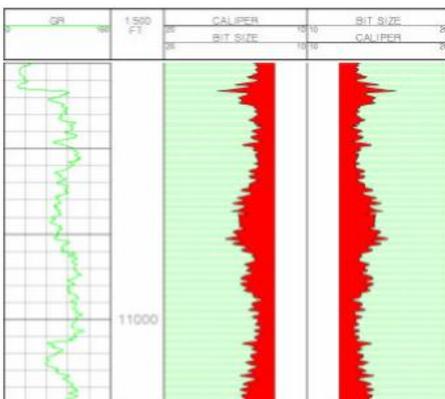
Description	RSS	Conventional Steerable Motor
Total Drilling Time (days)	2.18	8.43
Total Drilling Cost (Except Directional Drilling Tool)	\$ 108,508	\$ 419,942
Total Directional Drilling Tool Cost	\$ 58,825	\$ 42,313
Total	\$ 167,333	\$ 462,255

**BOREHOLE QUALITY**

Borehole quality plays an important role in the drilling process and also after the drilling process is finished. While the drilling process is conducted, good borehole quality can lower down the risk of Lost in Hole. After the drilling process is finished, the good quality borehole will have an impact in running casing process. The good quality borehole will improve the casing placement on bottom hence reduce the overall drilling rig cost. Figure 5 and 6 show the borehole quality comparison (using caliper log) between RSS and conventional steerable motor from wells in the Gulf Coast Area. This figure depicts that RSS produces smoother borehole than conventional steerable motor (Moody & Boonen, 2005).



**Figure 4.** Borehole Geometry Using RSS (Moody & Boonen, 2005)



**Figure 5.** Borehole Geometry Using Conventional Steerable Motor (Moody & Boonen, 2005).

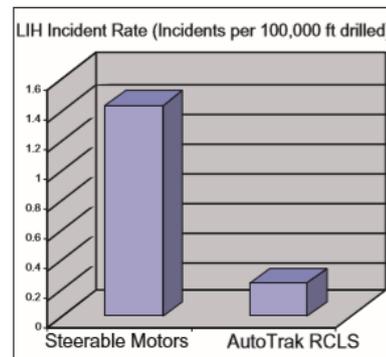
**LOST IN HOLE COST**

Lost In Hole (LIH) price for the directional drilling tool to be used should be considered. Table 6 shows the LIH cost for RSS and the conventional mud motor. The lost in hole cost of RSS is 7 times higher than the conventional steerable motor.

**Table 7.**  
*Lost in Hole Cost*

Description	RSS	Conventional Steerable Mud Motor
LOST IN HOLE COST	\$ 1,487,750.00	\$ 224,961.00

By seeing this Lost in Hole cost, it is easy to assume that RSS has a higher risk in making the drilling cost increase dramatically due to lost in hole event. But, LIH incidents risk using RSS is much lower. Even though lost in hole price of RSS is higher, there is a paper that stated the LIH rate of using RSS is much lower than conventional mud motor. Figure 4 shows a comparison of LIH incidents between RSS and conventional mud motor. From figure 4 we can see the rotary steerable system LIH rate was only 15% of the conventional systems (Ruszka, 2003).



**Figure 6.** Comparison Lost in Hole Incidents between Conventional mud motor vs RSS (Ruszka, 2003)

**CONCLUSION**

While many beliefs that conventional steerable mud motor is the most efficient solution for drilling operation, it is not always the case. Drilling data from Mavvar field shows that RSS increases ROP 4 times in build/drop section compared to conventional steerable motor. Even though the daily cost of RSS is 4 times higher than the conventional mud motor, in the end the total cost of drilling operation using RSS is 2.7 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 steerable motor. These conditions provide indirect benefit such as

reducing the time for casing installation and improving the quality of logging data. In conclusion, the application of RSS in Mavvar field not only gives technical advantages but also an economic advantage.

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