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RESEARCH ARTICLE

APPLICATIONS, DESIGN, AND KEY SUCCESS FACTORS FOR MOTORIZED ROTARY STEERABLE SYSTEM

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Abstract

Drilling oil and gas well is always a costly affair, and there has been a continuous push to reduce the cost by improving the well construction rate. In early times, well used to be vertical. When the need to drill directional wells arose, technology such as positive displacement motors with bent housing and rotary steerable systems (RSS) wereintroduced and drilled several directional wells. But both these technologies have some drawbacks. To perform directional work in the well with the Motor, sliding needs to be done which can cause a risk of stuck pipe. A Rotary steerable system (RSS) resolves the stuck pipe event to a great extent since directional work can be done in rotation mode. But the RPM available at the bit is only surface RPM (SRPM). To Counter this problem, the industry has developed the latest drilling technology that has the best of both technologies. The BHA consists of a Motor and an RSS. The motor provides extra RPM at bit and RSS does the directional work without any need for sliding. This technology has revolutionized the drilling envelope. These days Motorized RSS (MRSS) BHA has become a go-to BHA when a drilling engineer wants to achieve difficult well trajectories with drilling efficiencies. This paper discusses the various applications of this BHA along with Design and key success factors.

Introduction:-

In the world of oil and gas drilling, technological advancements are constantly pushing the boundaries of efficiency and performance. One such innovation that has revolutionized drilling operations is the Motorized Rotary Steerable System (RSS). This cutting-edge technology offers enhanced directional drilling capabilities, improved wellbore quality, and increased drilling efficiency. In this article, we will explore the features, benefits, and applications of the Motorized Rotary Steerable System and its significant impact on the oil and gas industry.

The Motorized Rotary Steerable System is a drilling tool designed to precisely control the direction and trajectory of the wellbore. Unlike traditional drilling methods that rely on the rotation of the entire drill string, the RSS uses a downhole motor to provide independent steering capabilities. This enables real-time adjustments to the drilling direction, allowing operators to navigate complex geological formations with greater accuracy and efficiency.

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Major Components Of MRSS
The MRSS BHA has 4 major components.

High-toque Positive Displacement Motor (PDM)
The motor provides the extra power, torque, and RPM needed at the bit. This is a positive displacement motor that has been utilized in the industry for a long period of time for directional and performance drilling. It has a power section consisting of a helical-shaped rotor and stator that convert hydraulic energy to mechanical (rotational) energy. Available PDMs in the industry are of multiple types depending on the power and torque theygenerate. The type depends upon the 3 parameters mentioned below:

1. Length of Power Section – Bigger the length of the power section, the higher the power motor generates.
2. Stator – Rotor lobes configuration – The higher the number of lobes in the stator/rotor, the higher the generated torque.
3. Stator type – All PDMs being used in the Industry have rubber-lined stators. The type of rubber lining changes the capacity of the PDM.
4. Transmission housing – This housing transmits the rotation power generated by the power section to the bearing assembly and finally to the bit.

For the MRSS application, not all types of PDM can be utilized because of the amount of load below the motor. In MRSS BHA, PDM is connected to bit via the Rotary Steerable Tool (RSS). Since the PDM must bear the load of RSS along with the bit, the load capacity of the PDM should be higher. That is the reason why high-performance PDMs are being used for this purpose. That high-performance PDM can be of high torque with a large number of stator-rotor lobes and a bigger power section along with even rubber stator lining. That provides greater load capacity to the PDM.

Rotary Steerable System (RSS)
The Rotary Steerable System (RSS) is the brain of MRSS BHA. RSS is composed of the below-mentioned main parts:

1. Control Unit (CU): The control unit is the brain of any RSS system. It consists of electronics and a sensor package. It is mounted by hangers with bearing packs inside a non-magnetic collar. This provides the directional controls for the Biasing or steering unit of the system.
2. Biasing / Steering Unit: This unit does the steering work for the system. This is a mechanical part of the system. This could be an external pad-type system that pushes the formation to perform the steering work or it could house a permanent bit shaft that points the bit to perform steering work.
3. E-mag receiver Unit: It consists of an electronics assembly with the antenna mounted inside of stabilized mandrel. It receives real-time data from CU via the electromagnetic link and sends the data to MWD tool via direct connection for onward sending up hole.

There are several RSS tools are available in the industry with different companies. However, the underlying technology remains the same. All these RSS can be classified into 3 types depending on the steering mechanism:

1. Push the bit: A pure “push the bit” rotary steerable system steers simply by applying a side load to the bit – usually using pads close to the bit to apply this load. This forces the bit’s outer cutting structure and gauges to cut sideways into the formation. This will drill a curved hole in that direction, therefore, achieving the desired well trajectory. Systems employing this principle are restricted to concise gauge bits (typically less than 2″ gauge length) where the gauge is set with an active cutting structure. While these systems are agile, permitting a quick and precise response to any required changes in wellbore deviation, the short gauge bits used by these systems may drill a “spiraled hole” when high-side loading is applied. [1]-[3]
2. Point the bit: Point-the-bit systems use the same principle as is employed in bent-housing motor systems. A pure “point the bit” RSS rotary steerable system steers by precisely pointing (tilting) the bit in the direction the well path needs to be steered. In doing so, the drill bit’s face points perfectly in the required direction, and there is no side loading on the bit. The advantage of this operating principle is that we can use longer gauge bits to avoid hole spiraling. Unfortunately, these systems are slower to respond to required trajectory changes, and the overall dogleg severity capability is typically lower than that of a “push the bit” system. [4]
3. Hybrid: As the name suggests, this type of RSS consists of both type of steering mechanisms push the bit and point the bit. [5],[6]

Real-time transmission tool

During oil and gas conventional drilling, all downhole data gets transmitted to the surface by MWD tool in the form of mud pulses. MWD tool collects the data from all tools connected downhole and converts that data into mud pulses. Since PDM is a fully mechanical part and it does not have any electronics. It cannot transmit any data directly to MWD tool. Also RSS is connected to PDM, therefore there is no direct electrical connection between MWD and RSS. To make a virtual connection between RSS (that generates lots of data with the help of sensors and a control unit) a tool is used which has two parts – sender and receiver. Sender is directly connected to the RSS and transmits data in the form of an electro-magnetic signal. The receiver is connected to MWD tool and receives the electro-magnetic signal converts itinto an electrical signal and sends it to the MWD tool.

Stabilization and Vibration Control Systems

Since the objective of the BHA is to perform the directional work along with providing the additional torque and RPM at the bit, the stabilization of the BHA plays an important role. There could be multiple stabilizers placed on the BHA which can provide the stabilization to make drill string stable. These systems help manage vibrations and maintain wellbore stability by reducing torsional and axial vibrations that can lead to equipment failure or wellbore damage.

The stabilization can also impact the overall steering capability of the drilling BHA with respect to its maximum dog leg capability.

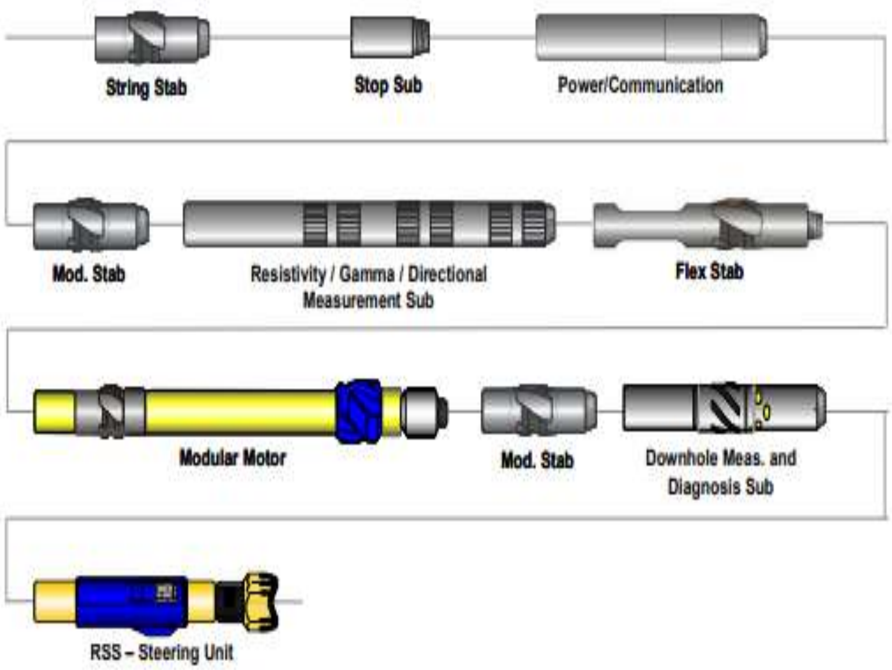

Fig-01:- Motor-powered RSS BHA with Integrated Downhole Diagnosis Tool Positioned Below the Motor [7]

Design consideration for the MRSS job

Hydraulics

Probably, one of the biggest design considerations for any Motorized Rotary Steerable system (MRSS) is the hydraulics. The MRSS BHA includes a PDM and RSS system. The PDM has a power section that generates power by hydraulic energy from the mud flow. That also creates a pressure differential. Especially in high torque motors, this pressure differential can be significant. This pressure differential adds upto the total surface pressure. Further, if push the bit RSS is being used in MRSS BHA, this hydraulics becomes more important as there is an additional requirement of back pressure at the pads which interacts with the formation to provide the steering action.

Finally, these hydraulic calculations can determine the mud pump liner sizes and number of mud pumps to be used during the operation.

Torque and Drag Analysis

Torque and drag analysis is a critical aspect of the drilling process in the oil and gas industry. It involves evaluating the forces that act on the drill string as it is being rotated and advanced into the wellbore. These forces include torque, which is the rotational force applied to the drill string, and drag, which is the axial resistance encountered as the drill string moves through the wellbore.

The main objective for this BHA is to provide additional torque/RPM available at the bit to increase the drilling performance. This analysis can help to determine how much Weight on Bit (WOB) can be given safely from the surface while making sure the downhole tools do not get damaged.

Vibration and oscillation analysis

The finite element analysis should be done while designing the stabilization to correct any severe to catastrophic vibrations. This analysis provides safe operating envelopes with respect to RPM, torque, and WOB to maximize the available mechanical specific energy (MSE) at the bit to perform drilling operations.

Rig Capacity

Depending on the rig capacity of handling the pressure and mud pump specifications, the hydraulic must be fine-tuned for a successful operation.

Key Success factors for MRSS Job

The success of a Motorized Rotary Steerable System (MRSS) is influenced by various factors that collectively contribute to its effectiveness, efficiency, and overall performance. These success factors play a crucial role in determining the system's ability to achieve accurate wellbore placement, reduce drilling time, and enhance overall drilling operations. Here are the key success factors for an MRSS in oil drilling:

Precision Steering Capability:

The MRSS should offer precise and responsive control over the wellbore trajectory, allowing operators to accurately navigate through complex geological formations and maximize reservoir exposure.

Real-time Data Monitoring:

Successful MRSS operations depend on the collection and transmission of real-time data from downhole sensors to the surface control unit. This data enables informed decision-making and adjustments.

Accurate Geosteering:

The MRSS's ability to integrate real-time geological data with its steering adjustments is crucial for geo-steering, ensuring the well trajectory stays within the target reservoir zones.

Reduced Drilling Time:

A successful MRSS reduces drilling time by minimizing the need for tool changes and reducing the non-productive time associated with conventional methods.

Enhanced Well Placement:

MRSS should enable optimal well placement within the reservoir, maximizing hydrocarbon recovery and reservoir contact.

Collision Avoidance:

Effective collision avoidance algorithms prevent wellbore collisions with adjacent wells or geological formations, ensuring safe drilling operations.

Wellbore Stability:

The MRSS should contribute to maintaining wellbore stability by reducing vibrations, shocks, and tortuosity, leading to smoother well trajectories.

Versatility:

A successful MRSS is versatile, capable of being used in various drilling scenarios, including horizontal, extended reach, and unconventional wells.

User-Friendly Interface:
The surface control unit's interface should be user-friendly, enabling operators to monitor drilling parameters, adjust steering settings, and make informed decisions easily.

Reliable Realtime Communication:
The communication system should provide uninterrupted and reliable data transmission between the downhole MRSS components and the surface.

Integration with Drilling Operations:
Successful integration of MRSS into existing drilling operations and workflows is essential for seamless operations and minimizing disruptions.

Maintenance and Support:
Adequate training, technical support, and predictive maintenance strategies contribute to the ongoing success of the MRSS during drilling campaigns.

Cost-effectiveness:
A successful MRSS offers a favorable cost-benefit ratio, delivering increased drilling efficiency, reduced operational costs, and improved well productivity.

Research and Development:
Ongoing research and development efforts to enhance MRSS capabilities, optimize algorithms, and address operational challenges ensure its long-term success.

Collaboration and Expertise:
Collaborative efforts between drilling engineers, software developers, and domain experts are vital for designing, implementing, and optimizing the MRSS.

Applications in Oil and Gas Industry
The Motorized Rotary Steerable System finds applications in various drilling scenarios, including:

Under-powered rig:
The biggest application of the MRSS system is for rigs that can not deliver a great amount of RPM and torque at the bit due to their specifications. In those scenarios, the MRSS system can be utilized to provide additional torque and RPM at the bit to increase the drilling efficiency. However, the mud circulating system needs to be capable of handling the pressure generated in the operation.

Catastrophic sticknslip and vibration scenarios:
In the vertical/near vertical wells, the probability of having severe stick-slip and forward/backward whirl are very high. MRSS BHA provides increases in the drilling parameter envelope to deliver enhanced drilling efficiency, especially in high compressive strength formations.

Horizontal and Extended-Reach Wells:
The RSS enables operators to drill longer horizontal sections and extended-reach wells with improved accuracy. This is particularly beneficial for reservoirs that require maximum contact for optimal hydrocarbon extraction.

Directional Drilling in Complex Formations:
In highly deviated or geologically challenging formations, the Motorized Rotary Steerable System offers precise steering control, allowing operators to navigate through tight corridors and reach target zones more effectively.

Wellbore Remediation and Re-Entries:
The RSS can also be employed in wellbore remediation and re-entry operations. It facilitates accurate re-entry into existing wellbores, providing access to additional reservoir zones or performing remedial operations without the need for costly sidetracking.

Casing wear:
In the case of high-angle well trajectories, the casing wear becomes a major issue due to long rotating hours. This can be reduced by using the MRSS BHA in which the requirement of SRPM is reduced. That effectively means less rotation of the whole drill string and in turn reduces the casing wear.

Conclusion:-
The Motorized Rotary Steerable System represents a significant advancement in drilling technology, offering operators unprecedented control, efficiency, and accuracy in wellbore placement. With its enhanced steering capabilities, the RSS has transformed drilling operations by reducing drilling time, increasing drilling efficiency, and improving wellbore quality. As the oil and gas industry continues to explore complex reservoirs and push drilling limits, the Motorized Rotary Steerable System will continue to play a vital role in maximizing production and optimizing drilling operations. Its ability to navigate challenging formations, minimize wellbore deviation, and enhance safety makes it a game-changer in the pursuit of efficient and cost-effective drilling. As technology continues to evolve, we can expect further advancements in the Motorized Rotary Steerable System, driving innovation and propelling the oil and gas industry forward into a new era of drilling excellence.

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