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Increasing Efficiency in Well Abandonment Utilizing Hydromechanical Slotting Tool

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Abstract

As the number of the wells designated for the abandonment or slot recovery operations increase, multiple challenges are faced during the barrier placement and removal of the casing. Achieving operational efficiency is crucial. Till now, conventional solutions included milling of the casing, throughout history, conventional solutions involved milling processes and the use of charges to establish channels for either barrier placement or cement remediation or reduction of stuck forces, thereby enhancing casing removal efficiency.

This paper will explain the new technology which includes a hydro-mechanical tool that creates the slots into the casing to allows the access behind. This innovative approach aims to significantly improve efficiency during the well abandonment phase. The tool's capability extends to breaking down the barite accumulation behind the casing or facilitating the precise placement of cement for sustained casing pressure solutions or annular cement remediation. The incorporation of this advanced technology marks a paradigm shift in addressing the challenges associated with well abandonment, offering a more streamlined and effective solution.

Technology Overview:

The Hydromechanical slotting tool stands as a hydraulic marvel, incorporating a slotting wheel within its body to redefine the operational landscape. Comprising three integral components—the slotting tool, jetting sub, and isolation sub—this dynamic trio collaborates seamlessly to revolutionize the slotting process, ushering in a new era of operational efficiency.

The tool's activation is initiated by applying pressure against an inverted float at its base. This sets in motion a piston that activates a blade wheel, systematically puncturing the casing multiple times per section, resulting in rows of slots with specified dimensions (e.g., approximately 18.5 slots per foot for 9-5/8" casing). The creation of angled slots significantly impacts the fluid dynamics, optimizing the jetting process.

Following the slotting process, each slot undergoes immediate jetting facilitated by a strategically positioned jetting nozzle, typically measuring 18/32" in diameter. Positioned directly above the slotting blade, this strategic placement ensures thorough jetting and cleaning behind the casing.

The Isolation Sub is a crucial component featuring diversion cups designed to redirect flow from the circumferential Jetting Sub nozzles below. Activation of these nozzles occurs during the washing cycle immediately following the completion of the slotting process. The presence of diversion cups transforms the Jetting Sub into a closed system, effectively jetting, flushing, and cleansing the area behind the casing in a circumferential manner.

This closed system exerts force, compelling the fluid into the annulus, establishing a well-defined communication path with the annulus. The identical flow path is harnessed for the introduction of cement behind the casing during the cementing phase, resulting in the placement of a durable and permanent barrier. This integrated process ensures the creation of a robust and reliable barrier, elevating well integrity to new heights.

Methods, Procedures and Process:

For the abandonment or the sustained casing pressure solution, there are multiple methods adapted by the industry for providing the solution. Some of the methods are explained below.

Pilot Milling

In employing this specific technique, the casing undergoes a milling process initiated from the top and extends to the predetermined depth, specifically targeting areas where sustained casing pressure is anticipated. This milling action effectively removes the steel, generating swarf that is then transported back to the surface for proper disposal. However, it's important to note that this method involves a meticulous and strategic approach, emphasizing the necessity to eliminate bottlenecks and prevent the accumulation of swarf in the flow lines.

The execution of this method demands thorough planning to ensure seamless operations. Key considerations include the removal of bottlenecks to optimize the overall efficiency of the process, and stringent measures are put in place to manage and prevent the build-up of swarf throughout the flow lines.

A critical component of this technique is the pilot mill, whose effectiveness is intricately linked to the design of milling inserts and the configuration of the bottom hole assembly. The success of the entire operation hinges on a variety of factors, including the choice of milling fluid, the careful optimization of operational parameters, and the precision in cutters design. The depth of the targeted section plays a significant role in determining the duration of operational hours required to successfully complete the application. As a result, this method often involves extended operational timelines, emphasizing the need for meticulous planning and execution.

Section Milling

A second technique employed for casing removal involves the use of a hydraulically expanded tool equipped with knives designed to mill the casing and remove a specific section, allowing for the placement of a barrier behind the casing, effectively addressing sustained casing pressure issues. This tool is ingeniously designed with various types of knives capable of navigating through the casing's internal diameter. Upon reaching the desired depth, hydraulic pressure activates the tool, causing the knives to expand outside the casing and mill down to remove the casing. The generated swarf is efficiently transported to the surface through fluid circulation.

Swarf Free- Section milling

An advancement in the sustained casing pressure solution is the implementation of swarf-free section milling. Handling swarf poses numerous challenges during milling, leading to reduced operational efficiency, decreased rate of penetration, and additional time to clear the swarf, delaying the well preparation for subsequent operations. This innovative technique addresses these challenges by depositing the swarf downhole, significantly reducing the time and effort required for swarf management. The system

incorporates hydraulic expandable knives with augers below for efficient swarf transport and a left-hand motor for upward milling, resulting in heightened operational efficiency for sustained casing pressure solutions.

Perf -Wash and Cement

Another approach to addressing sustained casing pressure involves using perforation guns to create holes in the casing. After perforations are completed, the annulus is washed using swab cups and fluid pressure. These perforations serve as conduits for washing behind the casing and creating voids for cement placement, preventing the migration of gas or hydrocarbons and forming an effective barrier. However, challenges such as controlling cement movement and dealing with eccentric casing standoff are associated with this technique. Additionally, a sump is required for dropping the guns. If sustained casing pressure persists, the conventional milling method is employed to establish a barrier.

Hydromechanical Slotting

This innovative solution combines hydraulic activation of the blade with mechanical force, achieved by either picking up or slacking off the string, to pierce the casing and create slots where a barrier is needed or to remove barite for slot recovery. The tool includes swab cups facilitating the cleaning and washing of the annulus behind the casing by pumping fluid through the slots. These same slots are utilized for cement placement to create a barrier. Notably, this technology eliminates the need for explosives, making it suitable for remote locations and alleviating health, safety, and environmental concerns.

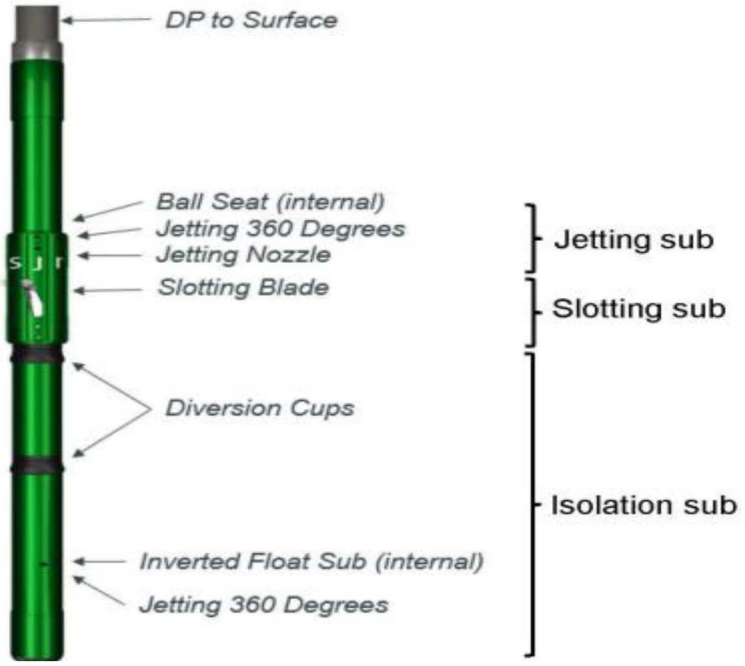


Figure. 1—Hydromechanical slotting Tool.

This shows the tool that incorporates the engine to create the slots as well as the nozzles for the washing as well as cementing.

Optimization in Well Abandonment using Hydromechanical Slotting tool.

Slot Shape

The configuration of the slot plays a pivotal role in establishing the void for effectively removing barite or facilitating optimal cement placement. Ensuring the right shape of the slot is essential to maximize the impact force of the fluid, enabling the best possible washing outcomes. The appearance of the pierced slot

resembles that of a garden hose, strategically shaped to generate the most efficient hydraulic impact force, ensuring thorough cleansing of sediments in the annulus behind the casing.

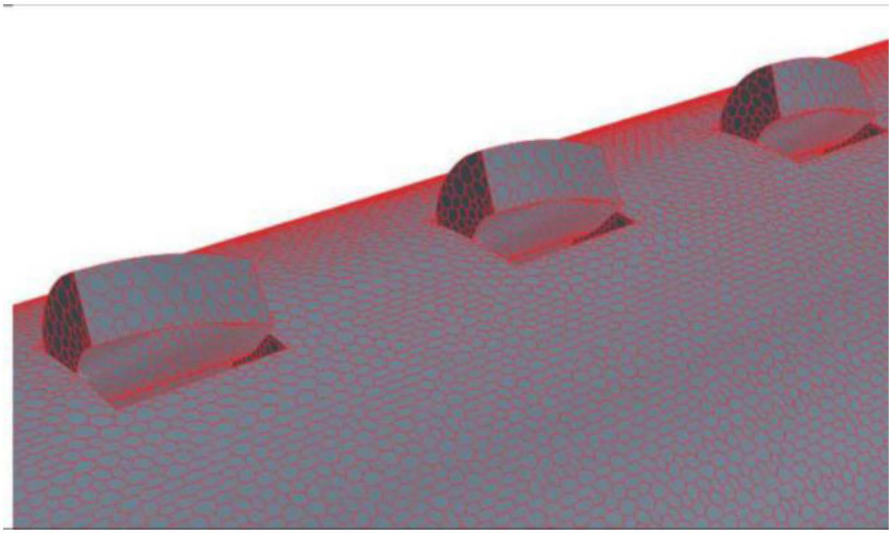


Figure. 2—Slots Shape

This shows the slots created by the hydraulic mechanical tool that allows the aid to the pumping fluid for the best possible cleaning or washing in annulus.

Circumferential Washing

The tools, with their well-defined slot shapes, coupled with simultaneous pumping, offer comprehensive circumferential cleaning. The fluid flow follows a pattern, wrapping around each created slot, providing a 360-degree washing effect. The strategic phasing of slots at 45 or 90-degree intervals, with fluid passing through each slot, amplifies the force, circumferentially cleaning and washing away debris. The synergy of slots on opposite sides of the casing enhances the overall cleaning efficiency.

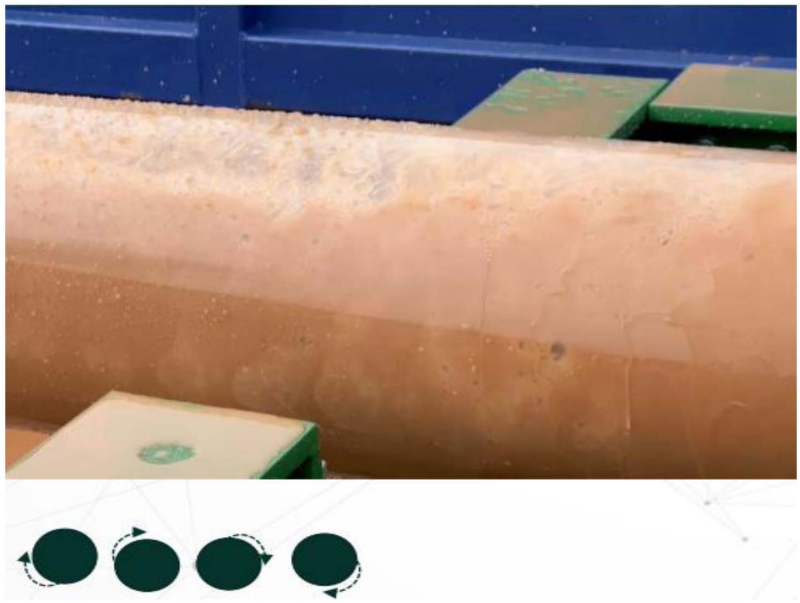


Figure. 3—Fluid Path

This shows the fluid paths followed as it is pumped thru the slots and washing action is achieved.

Standoff – Placement of the cement

The primary objective of creating a barrier is to establish a void for optimal cement placement. In high-inclination wells where casings are eccentric, achieving standoff is crucial to allow sufficient space for cement movement and prevent the migration of gas or hydrocarbons. The slotting tool uniquely pushes the casing away in a specific shape, ensuring standoff, surpassing other available methods in the market. This innovative approach guarantees a superior solution for effective cement placement and improved well integrity in challenging wellbore conditions.

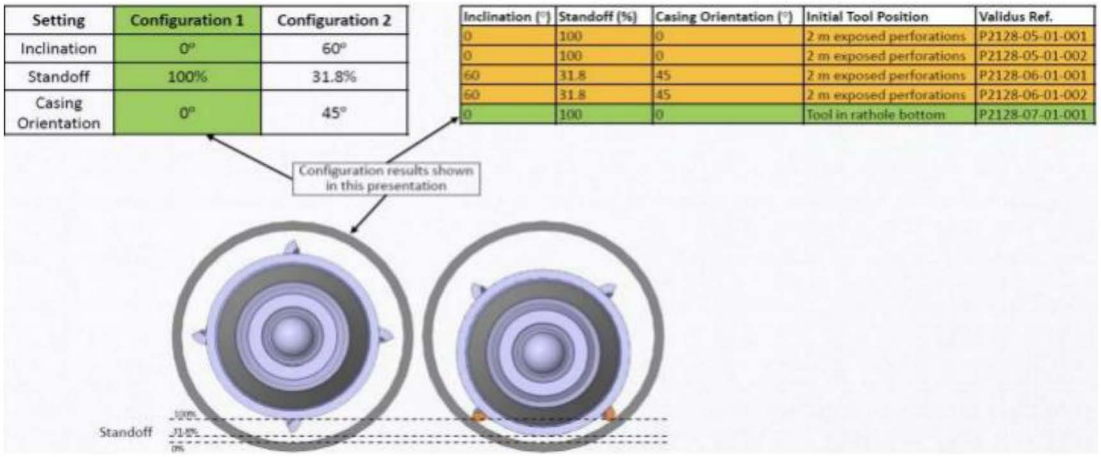


Figure. 4—Standoff Depiction

Stand off is shown by the slot created to create the void for the cement placement.

Results, Observations, and Conclusions:

Case Study No. 1:

For this special case study, the objective to remove the casing for the placement of the barrier during the plug and abandonment phase of the well.

1. The casing was 7.00", 32 ppf with P-110 grade.
2. The casing was cut at 1407m and attempted to pull but with no success. There was no communication in the annulus, so suspected settled barite behind the casing.
3. Three short slots were made, 950-951m and 945-945.5m for slotting down but unable to transfer the weight, tool was pulled out of the hole to change the configuration to upwards slotting.
4. On second run the slot were made from 898-889m and circulated out OBM bu positioning the cups on the uppermost slots. Further 135m was slotted from 1390-1255m and cleaned – Total of 1755 slots. Observed barite returns. Discrepancies in the tally raised multiple issues in broken wheel and tool was pulled out of the hole.
5. Tool was redressed for the third time and further slots were made, total of 3,055 slots were made. The casing was pulled with 83 tons overpull, total of 1407 m casing was pulled out of the hole and avoided the milling.

This run showed the performance as expected with functionality of the tool with some learning to improve the working and learning were recorded.

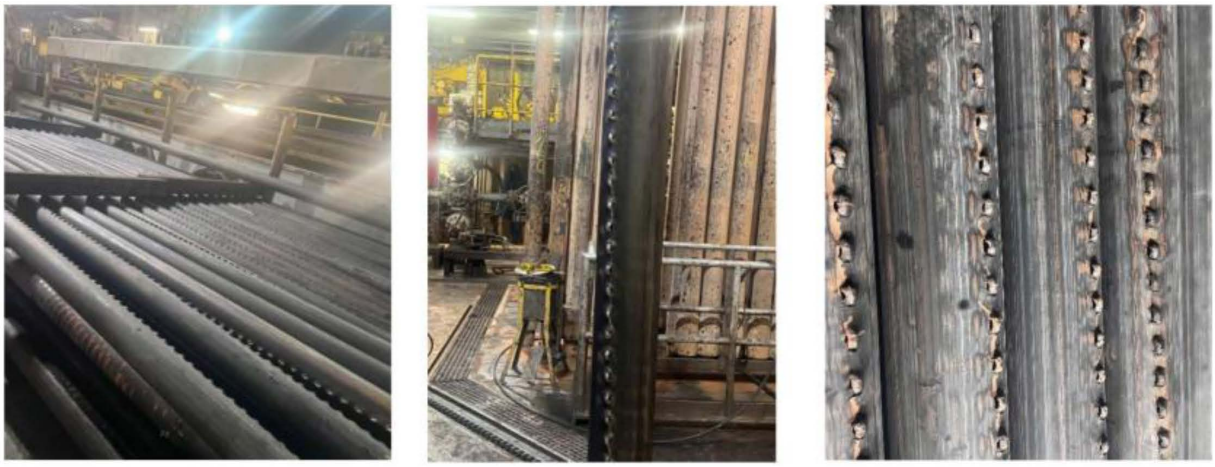


Figure. 5—Standoff Depiction

Slots made in the casing and recovered.



Figure. 6—Barite on shakes

Washing away for the barite to aid in pulling the casing by slotting and removing the stuck forces held caing.

Case Study No. 2:

In this scenario, the objective was to create slots into the 7" casing and place the cement to provide a barrier.

1. The slotting tool was utilized an successfully slotted 60m interval from 5986-5925m create 4 rows of the 9m slots in each casing section between the coupling sections. The slotting was achieved while jetting the slots clean at 234 gpm & 1820 psi.
2. The challenge encountered to achieve the one trip cementing by shearing out the flapper valve and decided to pull out of the hole.

3. On run 2 , tool was run with the flapper valve removed to enable the washing and cementing operation in 7" casing to proceed.
4. Washing was carried our at 1ft/min rate with 345 gpm and 2300 psi. This was completed with no returns at the surface. The slotting tool was picked up 5m into slotted area and 50 bbl of the Hi-Vis pilled was circulated ; followed by 12 ppg NAF circulated with 345 gpm and 2300 psi.
5. 494 bbls of 13 ppg spacer was pumped with cement united @ 6 bbl/min prior to pump 65 bbls of 13 ppg spacer @ 3.1 bbls/min.
6. Tool was ran back to bottom slot to commence cementing. Cement unit pumped 56 bbls of 16 ppg class G cement @ 6 bbl/min followed by 30 bbls of 13 ppg spacer.
7. Cement was pumped and pulled from 5983m to 5725m at 6bbls.min.
8. String was picked up to the TOL and circulated.
9. Cement was tested successfully to the 4015 psi.

The operation was planned to be completed in a single trip, but due to the challenges in shearing out the valve caused the second run to be executed. The job was completed and cementing job was completed showcasing the slots creation provide enough void to place cement and place a barrier.

Conclusion:

In conclusion, this paper has presented an exhaustive examination of the advancements in well abandonment techniques through the application of the hydromechanical slotting tool. The tool offers a distinctive approach to enhance operational efficiency, facilitating barrier placement or the removal of stuck forces behind the casing by creating channels for optimal washing or stuck force removal.

Whether addressing barrier placement in an inclined well or navigating highly challenging situations, this tool offers a non-explosive method by creating slots. These slots facilitate fluid jetting force, effectively cleaning behind the casing to establish a void for annular cleaning and a channel for cement placement.

This tool is a valuable addition to the array of technologies available in the market for addressing sustained casing pressure challenges. Its non-explosive nature and adaptability for single-trip operations contribute to a high level of operational efficiency with this innovative technology. The hydromechanical slotting tool emerges as a reliable and efficient solution, promising improved well integrity and streamlined operations in the oil and gas industry.

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