AADE-25-NTCE-060

14.5mm Hybrid Cutter Design: A Case Study

Cameron Devers and Casey Kitagawa, Taurex Drill Bits

Abstract

The selection of PDC cutter size is a critical factor in optimizing drilling performance, influencing rate of penetration (ROP), durability, and directional control. Traditionally, 13 mm and 16 mm cutters have been the primary options in PDC bit designs, each with distinct advantages and limitations. The 13 mm cutter prioritizes durability and stability but often sacrifices ROP potential, while the 16 mm cutter enhances cutting aggressiveness but is prone to higher torque fluctuations and faster wear in abrasive formations. To address these trade-offs, a 14.5mm hybrid cutter has been introduced as an intermediate solution, providing a balance between ROP, stability, and durability.

This study presents findings from field trials in both rotary steerable (RSS) and conventional motor applications, demonstrating the performance advantages of the 14.5mm cutter. In RSS drilling, it delivered an increase in ROP compared to 13 mm cutters while reducing torque instability observed with 16 mm designs, leading to improved tool face predictability. In motor-driven applications, the cutter enabled a significant increase in ROP over previous designs, with improved tool face control and reduced torque fluctuations, resulting in more efficient high-build-rate curve drilling.

Additional field runs in hard rock formations revealed that 14.5mm cutters exhibited superior wear distribution compared to 16 mm designs, reducing localized edge damage and extending bit life. Economic modeling suggests that this cutter size can contribute to fewer bit trips and lower overall drilling costs in extended lateral sections.

The results of this study indicate that the 14.5mm cutter represents a meaningful advancement in PDC bit technology, offering a scalable and effective solution across diverse drilling environments. Further optimization in cutter geometry and material advancements could further enhance its impact, making it a compelling alternative for future well construction strategies.

Introduction

Polycrystalline Diamond Compact (PDC) drill bits have become the dominant choice in modern drilling operations due to their ability to maintain high rates of penetration while withstanding extreme downhole conditions. The adoption of PDC technology since its introduction in the 1970s has been driven by improvements in cutter materials, bit body designs, and drilling system optimization. Early PDC cutters were limited in both durability and cutting efficiency due to manufacturing constraints and a limited understanding of how mechanical and thermal stresses impacted cutter performance Over the past several decades, advancements in cutter design, including variations in cutter geometry, chamfering, and diamond table reinforcement, have allowed PDC bits to significantly outperform roller-cone bits in most drilling applications. As a result, PDC bits now account for most footage drilled in both onshore and offshore environments (Watson et al. 2022).

One of the most influential factors affecting PDC bit performance is cutter size. The two most widely adopted cutter sizes in PDC drill bits have been 13 mm and 16 mm. The 13 mm cutter is often used in applications that demand high durability, greater thermal stability, and better directional control. However, the smaller cutting surface of the 13 mm cutter limits the depth of cut that can be achieved, which can restrict penetration rates in certain formations. In contrast, the 16 mm cutter provides a larger cutting surface, enabling a greater depth of cut and an increase in rate of penetration (ROP), particularly in softer formations or when aggressive drilling parameters are applied (Chen et al. 2026; Rahmani et al. 2020). The trade-off, however, is that the larger cutter size reduces the available diamond volume per unit of cutting edge, which may accelerate wear in hard formations and increase mechanical torque fluctuations, leading to directional control challenges.

This fundamental trade-off between durability, stability, and cutting efficiency has led to the investigation of alternative cutter sizes that could optimize performance across a broader range of applications. While cutter sizes both smaller and larger than 13 mm and 16 mm exist—such as 11 mm for highly abrasive applications and 19 mm for soft, high-ROP drilling—these sizes have seen limited adoption due to their specialized use cases. However, the introduction of a 14.5mm cutter has provided a compelling alternative that can bridge the performance gap between 13 mm and 16 mm designs. The 14.5mm cutter is large enough to improve ROP beyond what is achievable with 13 mm cutters while maintaining greater durability and smoother torque response compared to 16 mm cutters.

The development and implementation of a 14.5mm cutter have been driven by a growing need for a versatile solution that performs well across diverse drilling conditions, including mixed lithology wells and high-ROP curve and lateral applications. Field tests and numerical simulations suggest that the 14.5mm cutter can provide enhanced performance in both rotary steerable system (RSS) and conventional motor-driven drilling systems, balancing aggressiveness with directional stability. This paper examines the design principles, field applications, and comparative performance of the 14.5mm cutter in a variety of operational environments. By analyzing its impact on ROP, durability, and torque control, this study provides insights into how an intermediate cutter size can enhance drilling efficiency while extending bit life.

The 14.5mm Cutter Theory

The performance of a Polycrystalline Diamond Compact (PDC) drill bit is significantly influenced by the size and geometry of its cutters. Cutter selection impacts rate of penetration (ROP), durability, torque response, and stability (Figure 1) , making it a crucial factor in optimizing drilling performance. While 13 mm and 16 mm cutters have long been the standard choices in drill bit design, they each come with inherent trade-offs. The introduction of a 14.5mm cutter aims to address the performance gap between these two sizes, providing a more balanced approach to drilling efficiency and durability across a range of applications.

Influence of Cutter Size on Drilling Performance

Cutter size directly affects how a drill bit interacts with the formation. Larger cutters engage a greater surface area per revolution, increasing the volume of rock removed and, in many cases, improving ROP. However, larger cutters also generate higher torque and are more susceptible to mechanical and thermal stress. This can lead to increased cutter wear and reduced stability, particularly in hard and abrasive formations.

Smaller cutters, on the other hand, distribute cutting forces more evenly, leading to improved durability and greater control in directional applications. They are less prone to impact damage and allow for finer torque management but may limit instantaneous ROP due to their reduced cutting surface.

The 14.5mm cutter provides an intermediate solution that combines the benefits of both standard sizes. It offers a moderate increase in cutting efficiency over 13 mm cutters while maintaining better durability and directional control than 16 mm cutters. This balance allows for more predictable torque response, reducing the likelihood of excessive lateral vibrations and reactive torque fluctuations.

Figure 1 An example of tradeoffs in cutter related applications

Lithology-Specific Considerations

The effectiveness of a PDC cutter is highly dependent on the geological formations being drilled. Different lithologies present unique challenges that must be addressed through cutter size selection, chamfer optimization, and material enhancements.

Soft to Medium Formations (shale, limestone, siltstone): These formations allow for higher depths of cut with relatively low mechanical resistance. In such cases, a cutter with a smaller chamfer and a sharper edge maximizes ROP by efficiently shearing through the rock. The 14.5mm cutter provides an advantage over 13 mm cutters by allowing greater material removal without excessive torque fluctuations.

Interbedded Formations (sandstone-shale sequences, dolomite inclusions): These formations require a balance between cutting efficiency and impact resistance due to variations in hardness. A cutter that is too aggressive may experience excessive wear in harder sections, while a cutter that is too durable may struggle with penetration in softer zones. The 14.5mm cutter, when combined with an optimized chamfer profile, provides a stable compromise, ensuring efficient rock removal while maintaining durability.

Hard Rock Formations (quartz-rich sandstones, chert, carbonates): These formations pose a significant challenge for PDC cutters due to their high compressive strength and abrasiveness. Large cutters tend to experience early-stage wear due to edge degradation, while smaller cutters may lack the cutting efficiency needed to maintain ROP. The 14.5mm cutter, when reinforced with advanced diamond table engineering, may offer improved longevity compared to a 16 mm cutter while still achieving meaningful depth of cut.

By tailoring the design of the 14.5mm cutter to the demands of specific lithologies, drilling efficiency can be improved while maintaining bit integrity across a range of formation types.

Directional Stability and Torque Control

Maintaining stability during drilling is critical, particularly in applications where precise wellbore placement is required. Large cutters can introduce significant variations in side force, making them less predictable in rotary steerable system (RSS) applications. Smaller cutters provide greater directional control but may reduce instantaneous penetration rates.

The 14.5mm cutter provides a balance between these two extremes. Its size allows for higher ROP than a 13 mm cutter while maintaining better directional stability than a 16 mm cutter. When integrated into bit designs optimized for directional applications, the 14.5mm cutter has demonstrated improved tool face control and reduced lateral vibrations.

Field observations indicate that intermediate cutter sizes help mitigate drilling dysfunctions such as stick-slip and whirl by maintaining a more consistent torque profile. This contributes to better weight transfer to the bit, reducing energy losses and improving overall drilling efficiency.

Case Study: 14.5mm in RSS & Conventional Motor Applications

The introduction of the 14.5mm cutter was driven by a need to optimize the trade-offs inherent in standard 13 mm and 16 mm cutter sizes. To evaluate the effectiveness of this intermediate cutter size, field trials were conducted in various drilling environments, including rotary steerable system (RSS) applications and conventional motor-driven assemblies. These trials were performed in formations characterized by mixed lithologies, including shale sequences, interbedded sandstone, and carbonate formations, providing a diverse application to measure performance across different rock properties The goal of these trials was to quantify improvements in rate of penetration (ROP), torque stability, tool face control, and overall cutter durability in real-world operations.

The run bit designs were standardized to isolate the effect of cutter size on performance. Blade counts, nozzle configurations, and hydraulic optimization remained unchanged across the compared bits, ensuring that observed performance differences were attributable solely to cutter size. By implementing 14.5mm cutters in both RSS and motor applications, operators were able to examine how this intermediate size performed relative to traditional cutter options

Performance in Rotary Steerable System (RSS) Applications

In RSS drilling, maintaining high ROP while achieving precise tool face control is critical. One field trial examined the performance of the 14.5mm cutter in a curve and lateral section where trajectory control and stability were key factors. The run formation consisted of interbedded shale and limestone, requiring a balance between cutting efficiency and durability to minimize unplanned deviations and torque variations.

The results of this trial indicated that the 14.5mm cutter provided a measurable increase in ROP compared to the 13 mm cutter while demonstrating better stability than the 16 mm cutter. In directional control, the intermediate cutter size contributed to an improvement in tool face predictability compared to the 16 mm cutter, reducing erratic tool face movements that can negatively impact RSS. Additionally, torque fluctuations were observed to be significantly lower than those recorded with the 16 mm cutter, which is a crucial consideration in rotary steerable drilling, where excessive torque variations can reduce the system's ability to maintain trajectory.

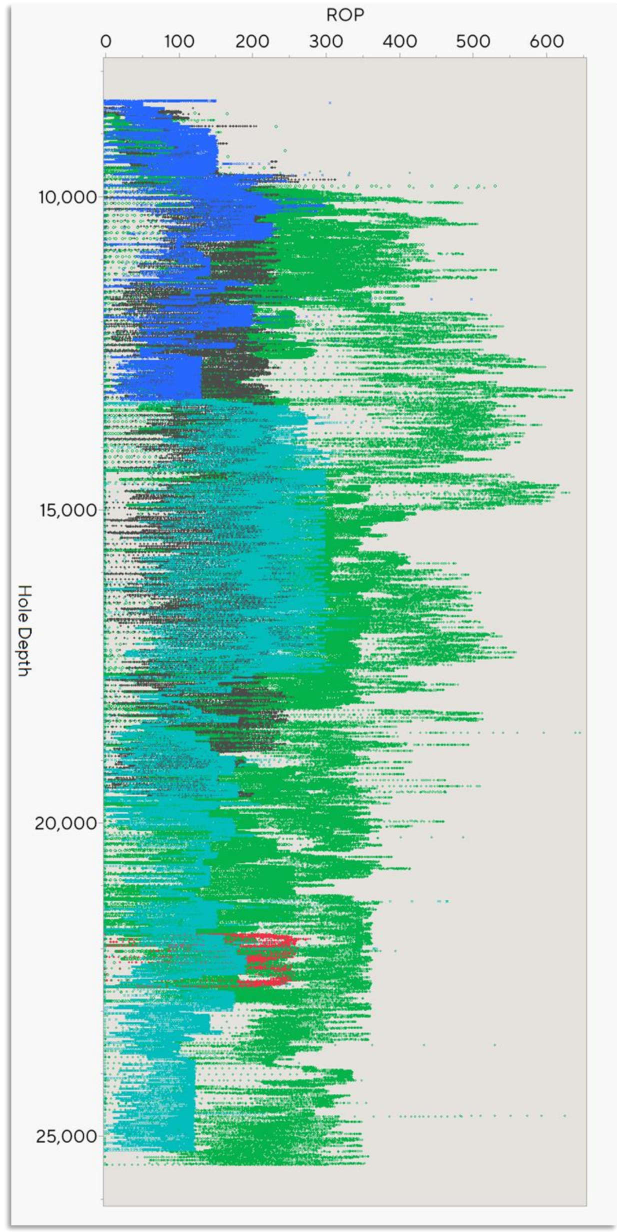

Figure 2 EDR report indicate substantial improvement in 14.5mm usage (Green Line)

Cutter wear analysis following the run showed that the 14.5mm cutter exhibited even wear distribution without excessive edge chipping or thermal degradation. This performance aligns with expectations for an intermediate cutter size, which engages a larger rock volume than a 13 mm cutter but avoids the excessive mechanical stresses seen in 16 mm configurations. Compared to previous RSS runs with traditional cutter sizes, the 14.5mm cutter demonstrated a more stable depth of cut while reducing lateral vibrations, suggesting a favorable balance between cutting aggressiveness and durability (Figure 2).

Performance in Conventional Motor Applications

In a separate field trial, the 14.5mm cutter was deployed in a high-build-rate curve section drilled using a conventional motor assembly. This application required an optimized balance between depth of cut and durability, as excessive aggressiveness could lead to premature motor stalling, while excessive durability could result in reduced penetration rates. The formation primarily consisted of alternating shale and sandstone sequences, with sections of dolomite inclusions that historically presented challenges for maintaining steady tool face control.

The results of the run demonstrated that the 14.5mm cutter delivered an 83% increase in average ROP when compared to the 13 mm cutter previously used in the same application. One of the most significant improvements observed in this trial was tool face control, where the optimized engagement of the 14.5mm cutter with the formation led to a 35% reduction in unwanted tool face deviations. This improvement resulted in smoother, more predictable directional adjustments and reduced the need for corrective steering inputs (Figure 3).

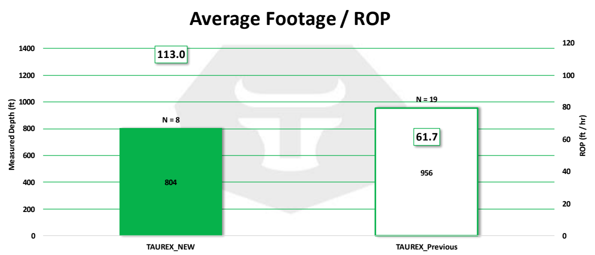

Figure 3 14.5mm cutters resulting in both a footage and ROP increase

Unlike the 16 mm cutter, which had previously been runed in similar formations, the 14.5mm cutter did not generate excessive torque fluctuations, a common issue that can lead to erratic motor performance. The torque profile during the trial remained within the expected range, mitigating risks associated with motor stalls or erratic downhole vibrations. Post-run dull grading also indicated that the 14.5mm cutter exhibited more uniform wear patterns compared to previous runs with 16 mm cutters, confirming that the intermediate size reduced localized stress concentrations while maintaining sufficient cutting efficiency (Figure 4 & Figure 5.

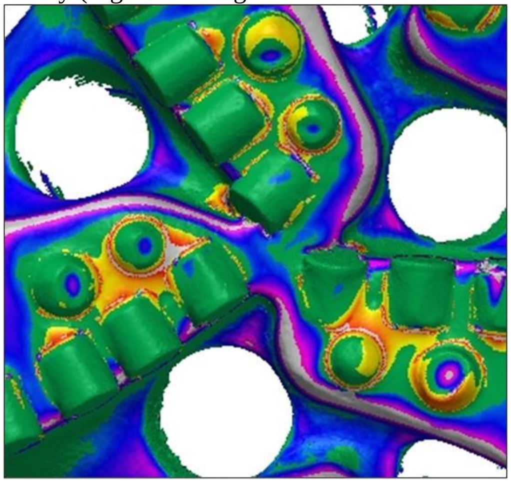

Figure 4 Incumbent dull state, non-green colors representing unwanted damage

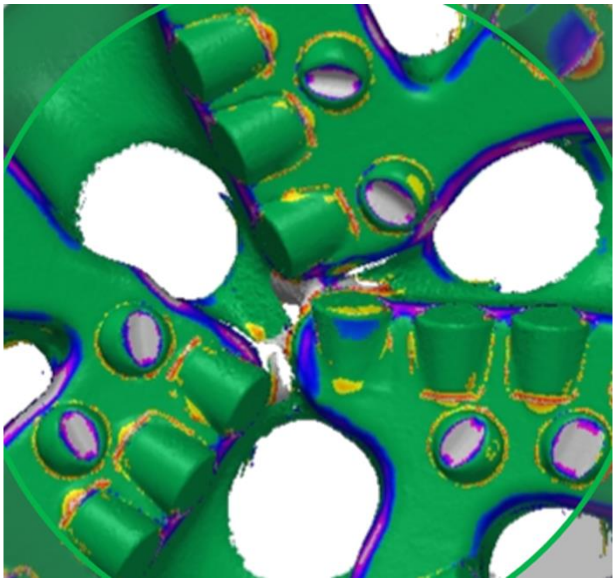

Figure 5 14.5mm dull, non-green colors representing unwanted damage

Comparison and Key Observations

Across both RSS and conventional motor applications, the 14.5mm cutter consistently demonstrated improvements in ROP, torque stability, and tool face control when compared to traditional cutter sizes. The controlled engagement of the cutter within the formation led to a more stable depth of cut, reducing the fluctuations that often impact drilling efficiency. Compared to the 13 mm cutter, the 14.5mm cutter provided a noticeable improvement in ROP while maintaining predictable torque responses. Compared to the 16 mm cutter, it exhibited lower lateral vibration and reduced tool face instability, leading to enhanced control in both RSS and motor-driven applications.

Another notable observation from these trials was the impact of cutter size on durability. The wear patterns on the 14.5mm cutter suggested that it avoided the excessive stress concentrations seen with 16 mm cutters, which are often prone to localized wear due to their larger engagement area. This balanced wear distribution contributed to extended cutter life, supporting longer runs with reduced risk of premature cutter degradation.

The field data supports the premise that an intermediate cutter size can provide a strategic advantage by delivering the benefits of increased ROP without compromising stability and durability. The trials also reinforce the concept that selecting a cutter size involves more than just maximizing cutting surface—stability, torque control, and directional predictability all play key roles in determining overall drilling performance

Case Study: Performance in Hard Rock Drilling

Drilling in hard rock formations presents unique challenges for PDC cutters, as high compressive strength and abrasiveness can lead to accelerated wear and reduced penetration rates. The

14.5mm cutter has been runed in various hard rock environments to evaluate its ability to balance durability, cutting efficiency, and torque stability. These runs were conducted in formations characterized by quartz-rich sandstones, dolomites, and carbonates, where traditional cutter sizes have exhibited distinct limitations.

The data from these trials was collected through field runs utilizing the 9.875” bit, which incorporated the 14.5mm cutter in hard rock applications. These runs focused on depth-averaged rate of penetration, cutter wear, and torque response, providing direct comparisons with standard 13 mm and 16 mm cutter configurations.

Field Performance in Abrasive Hard Rock

One of the key concerns in hard rock drilling is cutter longevity. Large cutters, such as 16 mm designs, often suffer from localized thermal degradation and edge spalling, which can limit run life in formations with high quartz or carbonate content. Conversely, smaller cutters, such as 13 mm designs, can lack the necessary aggressiveness to achieve efficient rock failure, resulting in lower ROP.

The 14.5mm cutter demonstrated an ability to maintain cutting efficiency while reducing localized stress concentrations that contribute to premature failure. Field results from multiple run runs indicated that the 9.875” bit achieved a more consistent DAR over extended footage, demonstrating lower fluctuations in penetration rates compared to previous runs using 16 mm cutters. These results suggest that the 14.5mm cutter engaged the formation more effectively without experiencing the same degree of cutting inefficiencies caused by torque spikes.

Post-run cutter inspections further reinforced these findings. The 14.5mm cutters exhibited a more uniform wear pattern, with no evidence of excessive edge degradation or uneven wear along the cutting surface. This is a critical factor in hard rock drilling, as uneven wear often leads to unbalanced bit behavior, reducing drilling efficiency and increasing the likelihood of bit damage. The performance characteristics observed in these runs support the hypothesis that intermediate cutter sizes distribute cutting forces more effectively, leading to a reduction in mechanical inefficiencies Figure 6.

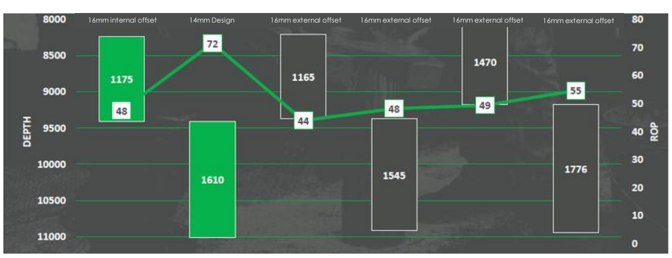

Figure 6 Pad comparison highlighting the overall success of the 14.5mm bit in comparison to several offsets

Comparative Performance and Cutter Wear Analysis

A final assessment of cutter dull grading and wear distribution was performed following these field runs to evaluate how the 14.5mm cutter compared to existing designs in terms of longevity and durability. The analysis revealed that:

- The 14.5mm cutters maintained structural integrity longer than 16 mm cutters, which showed more signs of localized fracture damage in abrasive sections.
- Uniform wear patterns were observed across multiple runs, whereas 16 mm cutters tended to exhibit asymmetrical edge wear in certain high-compression environments.
- Lower diamond volume loss per foot drilled was recorded, indicating that the 14.5mm cutter achieved greater efficiency in material removal while maintaining durability.

These results provide strong evidence that the 14.5mm cutter mitigates several of the failure mechanisms observed in both smaller and larger cutter sizes, reinforcing its value as an optimized solution for hard rock drilling applications.

Implications for Drilling Efficiency & Bit Longevity

The successful field performance of the 14.5mm cutter in a variety of drilling conditions raises important questions about its broader impact on efficiency, cost-effectiveness, and long-term viability. While individual case studies demonstrate measurable improvements in rate of penetration (ROP), torque stability, and durability, a larger perspective is required to assess how this cutter size could reshape bit design philosophy and well construction economics.

The balance achieved by the 14.5mm cutter—offering higher ROP than 13 mm while improving stability over 16 mm—positions it as a compelling option for operators looking to optimize drilling performance without sacrificing bit longevity. This section explores how these advantages translate into operational and economic benefits for modern drilling programs.

Enhanced Drilling Efficiency & ROP Gains

One of the most immediate advantages observed with the 14.5mm cutter is its ability to improve ROP without introducing excessive instability. In multiple field runs, bits equipped with this cutter size demonstrated ROP increases of up to 83% in conventional motor applications compared to previous designs using 13 mm cutters. Similar trends were observed in rotary steerable drilling, where tool face control and torque predictability played crucial roles in maintaining efficient drilling conditions.

Beyond ROP, drilling efficiency is also determined by mechanical specific energy (MSE), which represents how much energy is required to remove a given volume of rock. The 14.5mm cutter, due to its intermediate size, has shown lower MSE values than 16 mm cutters in comparable applications, indicating a more effective transfer of energy into material removal. This advantage suggests that the 14.5mm cutter can achieve high ROP while reducing wasted energy, which in turn improves bit and BHA efficiency.

Impact on Bit Longevity & Wear Distribution

The ability of a cutter to maintain efficiency over extended footage is crucial for reducing drilling costs. One of the key observations from field trials was that 14.5mm cutters exhibited more uniform wear patterns than 16 mm cutters, which tend to experience localized damage along the cutting edge in high-impact formations.

Dull grading data from post-run inspections confirmed that:

- 16 mm cutters showed more evidence of edge chipping and fracture damage, particularly in abrasive and interbedded lithologies.
- 13 mm cutters exhibited lower rates of failure but also struggled to maintain high ROP, limiting their overall footage potential.
- 14.5mm cutters demonstrated an optimal balance, sustaining sharper cutting edges for longer intervals without introducing excessive mechanical stresses.

This data reinforces the idea that the intermediate cutter size mitigates the most common durability concerns seen with both smaller and larger cutters, leading to longer effective bit runs and fewer premature pull-outs.

Economic Benefits: Cost Per Foot & Bit Trip Reduction

From a financial standpoint, one of the most important metrics in bit selection is cost per foot drilled. While cutter durability and ROP both factor into this equation, another major cost driver is the number of bit trips required over the course of a well.

The improved longevity and wear resistance of the 14.5mm cutter directly contribute to fewer required bit trips, which can lead to substantial cost savings in extended-reach horizontal drilling. In regions where well sections exceed 10,000 feet of lateral footage, minimizing bit replacements is critical for maintaining efficient drilling schedules.

Economic modeling based on trial data suggests that:

- In RSS applications, operators using 14.5mm cutters extended bit life by 15–25%, allowing for fewer bit runs per well.
- In motor-driven applications, the combination of higher ROP and better torque stability reduced the number of trips required to complete curve and lateral sections.
- Across both applications, the net effect was a measurable reduction in total well construction costs, particularly in unconventional resource plays where long lateral sections are common.

Scalability Across Different Formations & Well Designs

While the 14.5mm cutter has shown strong initial results, its long-term viability depends on its ability to scale across different geological environments and drilling programs. Current data suggests that this cutter size provides benefits in a range of formations, including:

- Soft to medium-strength formations (shale, limestone, siltstone) → Higher ROP without excessive durability concerns.
- Interbedded formations (sandstone-shale sequences, dolomite inclusions) → Balanced wear distribution, reducing edge failures common with larger cutters.
- Hard rock formations (quartz-rich sandstones, chert, carbonates) → Better wear resistance than 16 mm, while maintaining stable cutting engagement.

Additionally, the compatibility of 14.5mm cutters with both RSS and motor-driven drilling suggests that they can be applied flexibly across various BHA configurations, making them a scalable solution for future well designs.

Conclusion

The results from field trials and comparative analyses reinforce the effectiveness of the 14.5mm cutter as an optimized solution bridging the performance gap between 13 mm and 16 mm designs. Across various drilling applications, this intermediate cutter size has demonstrated significant improvements in rate of penetration (ROP), tool face control, and torque stability, while also maintaining a more uniform wear profile than its counterparts. These advantages position the 14.5mm cutter as a valuable tool for enhancing drilling efficiency, reducing operational costs, and improving wellbore quality.

Summary of Key Findings

Field data collected from rotary steerable system (RSS) and conventional motor applications highlight the distinct advantages of the 14.5mm cutter over existing industry standards. Compared to 13 mm cutters, the 14.5mm design consistently achieved higher ROP while maintaining predictable torque responses, making it an attractive choice for operators seeking to increase drilling speed without compromising stability. When evaluated against 16 mm cutters, the 14.5mm configuration provided lower torque fluctuations and improved directional control, reducing the risk of drilling dysfunctions that commonly arise from excessive cutter engagement with the formation.

Additional performance metrics further support the practical benefits of this cutter size. In hard rock formations, 14.5mm cutters exhibited more uniform wear distribution than 16 mm designs, which often suffered from localized damage along the cutting edge. This advantage was particularly evident in high-abrasion environments, where excessive cutter aggressiveness can lead to premature failure. Moreover, in extended-reach horizontal wells, the improved torque response and depth-of-cut consistency contributed to longer bit runs, fewer trips, and lower cost per foot drilled.

Future Research & Development

While the 14.5mm cutter has already demonstrated its potential across a range of drilling applications, continued optimization is necessary to fully maximize its benefits. Future research efforts should focus on:

1. Expanded field trials in extreme conditions – While initial runs have validated the 14.5mm cutter's durability in mixed and hard rock formations, further studies in ultra-high compressive strength formations could provide additional insights into its long-term reliability.
2. Comparisons in additional drilling systems – Evaluating the 14.5mm cutter's performance in hybrid BHAs, underbalanced drilling, and managed pressure drilling (MPD) could expand its applicability.
3. Expand utilization volume to examine complex failure trends – As complex image analysis systems grow and develop, the ability and subsequent obligation to better understand PDC cutter complex failure grows; new PDC technologies especially.

By addressing these areas, future cutter designs could build upon the foundation established by the 14.5mm concept, leading to further advancements in PDC bit technology and overall drilling efficiency.

Industry Implications & Long-Term Adoption

As operators continue to seek improvements in drilling performance and cost efficiency, the adoption of 14.5mm cutters is expected to grow. The findings presented in this study suggest that the intermediate cutter size offers a well-balanced solution for a wide range of drilling environments, making it an attractive option for future bit designs.

The ability of the 14.5mm cutter to extend bit life, reduce trips, and maintain high ROP has clear implications for well construction costs. Additionally, its compatibility with both RSS and motor-driven applications suggests that it can be scalably implemented across different drilling strategies, allowing for greater flexibility in bit selection.

Long-term adoption of this cutter size will depend on continued validation through additional field trials, as well as further improvements in cutter durability, material engineering, and design customization. However, based on current performance metrics, the 14.5mm cutter represents a meaningful step forward in PDC cutter technology, with the potential to become a new industry standard for high-performance drilling applications.

Final Thoughts

The results presented in this study demonstrate that incremental improvements in cutter size selection can yield substantial benefits in drilling performance. The 14.5mm cutter has proven to be an effective alternative to traditional 13 mm and 16 mm configurations, addressing longstanding trade-offs between aggressiveness, durability, and stability.

As more operators integrate this cutter size into their drilling programs, the findings from this research will serve as a foundation for further optimization and innovation in PDC bit technology. The continued evolution of cutter design, driven by field data and engineering advancements, will play a critical role in shaping the next generation of high-efficiency drilling solutions

References

Chen, S., Grosz, G., Anderle, S.et al. . 2016. The Role of Rock-Chip Removals and Cutting-Area Shapes in Polycrystalline-Diamond-Compact-Bit Design Optimization. SPE Drill & Compl30 (04): 334–347. https://doi.org/10.2118/171833-PA.

Rahmani, R., Pastusek, P., Yun, G. et al. . 2020. Investigation of Geometry and Loading Effects on PDC Cutter Structural Integrity in Hard Rocks. Paper presented at theIADC/SPE International Drilling Conference and Exhibition, Galveston, Texas, USA, March 3–5 https://doi.org/10.2118/199598-MS.

Watson, W., Dupriest, F., Witt-Doerring, Y.et al. . 2022. IADC Code Upgrade: Bit and BHA Forensics Using Rig-Based Photographic Documentation Practices. Paper presented at theIADC/SPE International Drilling Conference and Exhibition, Galveston, Texas, USA, March 8–10 https://doi.org/10.2118/208707-MS.