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Research Article

Reducing Non-Productive Time: Strategies for Cost Optimization in Offshore Drilling Operations

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Abstract

Reducing Non-Productive Time (NPT) is critical for cost optimization in offshore drilling operations, where operational efficiency directly impacts financial performance. NPT, which refers to periods when drilling activities are halted or progress is significantly slowed, can lead to substantial financial losses and project delays. Effective strategies for minimizing NPT are essential for optimizing costs and enhancing overall drilling performance. This paper adopted a descriptive approach in evaluating key strategies for reducing NPT through Lean methodologies, such as Define, Measure, Analyze, Improve, and Control (DMAIC) framework, which helps to eliminate waste and non-value-adding activities. Improved process efficiency results in faster operations and reduced downtime, contributing to significant cost savings. Effective resource management, including optimized crew deployment and inventory management, further supports cost reduction by avoiding overstocking and ensuring optimal use of resources. The paper concluded that reducing NPT through predictive maintenance, parameter optimization, process efficiency, and resource management using Lean Six Sigma Method is crucial for cost optimization in offshore drilling operations. These strategies collectively enhance operational performance, leading to financial and efficiency gains in the industry.

Keywords

Non-Productive Time, Offshore Drilling, Cost Optimization, Drilling Operations

1. Introduction

Drilling in petroleum engineering refers to the process of creating a borehole in the Earth's subsurface to access potential hydrocarbon reservoirs. This process is guided by drilling engineering, which oversees the design, organization, and construction of wells used in exploration and development. Drilling plays a crucial role in the initial phases of an oil or gas well's life cycle. First, during the *Exploration phase*, wells are drilled to detect hydrocarbons and gather geological data for evaluating the formation. Next, in the *Appraisal phase,* further wells are drilled to validate and expand upon the data from exploration, helping to confirm the reservoir's viability. Finally, in the *Development phase*, once a Field Development Plan (FDP) is approved, development wells are drilled, completed, and connected to production infrastructure to enable the extraction of hydrocarbons. Each phase builds upon the previous one, ensuring the safe and efficient development of oil and gas resources [2].

Oil and gas companies typically do not drill wells on their own because they lack the necessary drilling equipment and specialized personnel. Instead, they hire *drilling contractors*

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who are responsible for maintaining the drilling rigs and employing skilled staff to execute the drilling operations. These contractors do not generate revenue directly from petroleum production, as their role is limited to drilling services. The primary expectation of oil and gas companies when outsourcing drilling work is that the drilling contractor completes the task efficiently, following the *designated drilling program*. This involves adhering to safety protocols, maintaining high-quality standards, and finishing within the agreed time frame and budget. The successful completion of the drilling work without compromising on safety, quality, or cost is vital, as it sets the foundation for subsequent phases of oil and gas production. Thus, collaboration between oil companies and contractors is crucial for the operational success of oil exploration and development projects [2].

Drilling operations face various challenges that, if not addressed adequately, can lead to significant issues such as health, safety, and environmental (HSE) risks, equipment damage, or non-productive time (NPT). *Drilling NPT*refers to periods when drilling activities are halted or the penetration rate drops to unusually low levels [10]. This downtime can negatively impact project timelines and costs. NPT events are broadly categorized into two groups: *geological or subsurface-related issues* and *non-geological causes* [7]. Geological factors may include unexpected rock formations, pressure imbalances, or difficult-to-drill zones, while non-geological causes could stem from equipment failure, human errors, or logistical problems. These challenges highlight the importance of proper planning, monitoring, and mitigation strategies to avoid costly delays and ensure the safety and efficiency of drilling operations. Reducing NPT is crucial for optimizing drilling performance and minimizing risks. Therefore, this study evaluatedthe adoption of Lean Six Sigma Methodology in reducing NPT and optimizing performance.

1.1. Statement of Problem

Non-productive time (NPT) in offshore drilling operations presents a significant challenge, as it leads to costly delays, safety risks, and inefficiencies. NPT occurs when drilling activities are interrupted or slow down due to issues such as equipment failure, challenging geological conditions, or operational errors. In the high-stakes environment of offshore drilling, NPT not only increases operational costs but also extends project timelines, impacting overall profitability. Additionally, prolonged NPT can escalate health, safety, and environmental (HSE) risks, further complicating the drilling process. Therefore, minimizing NPT is critical to ensuring the economic viability and safety of offshore drilling projects.

1.2. Objective

The paper examined the reduction of NPT in offshore drilling operations for cost optimization using Lean Six Sigma method.

2. Conceptual Review

2.1. Non-Productive Time (NPT)

Non-Productive Time (NPT) in drilling operations refers to the periods when scheduled activities are delayed, interrupted, or stopped due to unforeseen problems, resulting in downtime or inefficiencies. This downtime occurs when drilling operations are not progressing as planned, either because of technical issues, logistical challenges, equipment failures, or external factors like adverse weather conditions [5]. NPT is a critical metric in the oil and gas industry because it directly impacts the overall cost and timeline of drilling projects, making it a key focus area for improving operational efficiency. NPT is typically categorized into two main groups*: geological or subsurface-related causes* and *non-geological causes* [7]. Geological causes can include unexpected formation pressures, borehole instability, or challenging subsurface conditions. Non-geological causes are often related to equipment failure, human error, or logistical delays [10]. These delays not only increase project costs but also pose health, safety, and environmental (HSE) risks. Recent advancements in technology and data analytics have allowed for better tracking and mitigation of NPT. By leveraging real-time data monitoring and predictive maintenance, companies can proactively address issues that lead to NPT, reducing downtime and improving overall drilling performance [16]. Managing and minimizing NPT is crucial for optimizing drilling efficiency, reducing operational costs, and ensuring the profitability of oil and gas projects.

2.2. Lean Six Sigma Method

Lean Six Sigma is a comprehensive process improvement methodology that integrates two powerful concepts: *Lean* and *Six Sigma*, each with its origins and focus areas.

Lean principles originated from the Toyota Production System (TPS), developed by Toyota to enhance manufacturing efficiency [3]. The core of Lean is to eliminate waste, defined as non-value-adding activities that deplete resources without contributing to customer value. By identifying and removing these wastes, Lean aims to streamline processes, increase speed, and improve overall efficiency. Six Sigma, developed by Bill Smith at Motorola, focuses on reducing variation within processes to ensure consistent quality [4]. Six Sigma measures process performance by the number of defects or deviations from quality standards. A process is considered to operate at a Six Sigma level if it produces only 3.4 defects per million opportunities, indicating a defect rate of 0.00003% and a near-perfect quality level of 99.99967% [4].

Lean Six Sigma combines these approaches to create a data-driven framework for problem-solving and decision-making. By leveraging Lean's emphasis on waste reduction and Six Sigma's focus on minimizing variation, organizations can achieve significant improvements in process efficiency and product quality. This methodology has been widely adopted by leading companies, such as General Electric (GE), to enhance operational performance and deliver superior results [3]. Also, Six Sigma focuses on reducing variation in drilling operations. In offshore drilling, variations can arise from inconsistent drilling speeds, equipment failure, or unpredictable geological conditions. By applying Six Sigma's data-driven approach, drilling teams can identify the root causes of these variations, implement measures to control them, and improve process reliability. Techniques like Define, Measure, Analyze, Improve, and Control (DMAIC) are employed to systematically enhance drilling performance.

2.3. Theoretical Framework

Lean Thinking is a management philosophy focused on eliminating waste [15]. In offshore drilling, waste manifests in the form of downtime, unnecessary movement, equipment failure, and delays in supply chain logistics [11]. By focusing on streamlining operations and improving workflow efficiency, Lean principles aim to reduce non-value-adding activities in drilling processes. This approach helps drilling contractors and oil companies minimize non-productive time (NPT), leading to cost savings and enhanced operational safety [15].

Lean Thinking is underpinned by the *Theory of Constraints (TOC),* developed by Goldratt [8], which posits that every process has at least one limiting factor or "constraint" that restricts its performance. In offshore drilling, these constraints may include mechanical downtime, logistical inefficiencies, or geological challenges. The goal is to identify and manage these constraints to improve the overall system's performance [9]. In practice, TOC helps offshore drilling operations focus their efforts on optimizing key bottlenecks in the drilling process, ensuring that critical resources are effectively managed to minimize NPT.

3. Methodology

Adopting Lean Six Sigma in offshore oil drilling involves a structured approach using the Define, Measure, Analyze, Improve, and Control (DMAIC) framework. This methodology helps to systematically enhance operational efficiency, reduce non-productive time (NPT), and improve overall performance. Below is a critical elaboration of each step in the DMAIC technique, illustrated with a flowchart diagram.

Define: Clearly define the problem, project goals, and scope.

In the Define phase, the primary focus is on identifying and articulating the specific issues affecting offshore drilling operations. This includes understanding the key problems such as excessive NPT, equipment failures, or inefficient processes. The project team should establish clear objectives, scope, and deliverables, and identify stakeholders involved [14]. For instance, if a drilling operation is facing frequent delays due to equipment failures, the Define phase will involve detailing the problem, such as the impact of these failures on overall drilling performance and safety.

Measure: Quantify the current performance and identify baseline metrics.

During the Measure phase, the goal is to collect data on current processes and performance metrics to establish a baseline for comparison. In offshore drilling, this involves measuring various parameters such as drilling speed, equipment downtime, fuel consumption, and safety incidents. Accurate data collection is crucial to understanding the extent of the issues and identifying key performance indicators (KPIs) that will be used to gauge improvements [1]. For example, measuring the amount of NPT and its causes can provide insights into specific areas where improvements are needed.

Analyze: Identify the root causes of problems and inefficiencies.

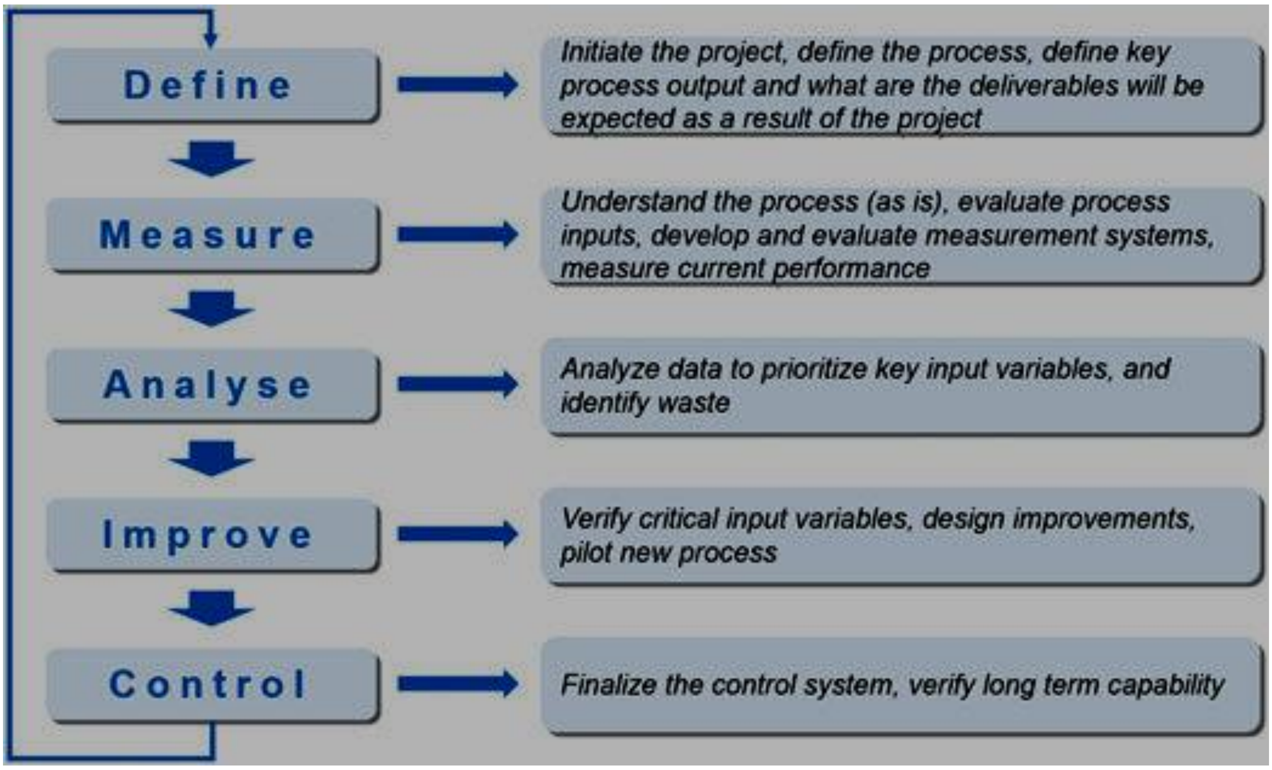
In the Analyze phase, the collected data is examined to identify the root causes of inefficiencies or problems in the drilling process. Techniques such as cause-and-effect diagrams, statistical analysis, and process mapping are used to uncover the underlying issues contributing to NPT or other operational problems [7]. For instance, analyzing data might reveal that equipment failures are linked to insufficient maintenance or outdated technology. Understanding these root causes is critical for developing effective solutions.

Improve: Develop and implement solutions to address the identified issues.

The Improve phase focuses on designing and implementing solutions to address the root causes identified in the Analyze phase. This may involve process redesign, upgrading equipment, or introducing new technologies to enhance efficiency. In offshore drilling, improvements might include adopting predictive maintenance techniques, optimizing drilling parameters, or streamlining logistics and supply chain operations [12]. For example, implementing a real-time monitoring system could help detect equipment issues before they lead to significant downtime, thereby reducing NPT.

Control: Ensure that improvements are sustained over time and maintain performance.

The Control phase is about establishing measures to ensure that the improvements are sustained and that performance remains consistent over time. This involves implementing control plans, monitoring systems, and periodic reviews to ensure that the changes have the desired effect and that new issues are promptly addressed. For offshore drilling, this might include regular performance audits, continuous training for staff, and maintaining updated maintenance schedules [9]. Effective control mechanisms help in sustaining the gains achieved through the Lean Six Sigma project and ensuring long-term operational excellence.



Source: Google, 2024

Figure 1. *Diagram of DMAIC Framework.*

4. Relevance of Lean Six Sigma Method

Lean Six Sigma, when applied to offshore oil drilling, offers significant advantages in reducing Non-Productive Time (NPT) and optimizing costs. The synergy between Lean principles and Six Sigma methodologies facilitates a comprehensive approach to improving operational efficiency and enhancing profitability.

1. *Minimizing Equipment* Downtime: Equipment downtime is a major contributor to NPT in offshore drilling. Lean Six Sigma's focus on reducing variation and eliminating waste can significantly minimize equipment failures and associated downtime. Lean Six Sigma methodologies can be applied to improve maintenance practices through predictive maintenance and real-time monitoring [1]. By employing Six Sigma tools like Failure Mode and Effects Analysis (FMEA) and Root Cause Analysis (RCA), organizations can identify and address the underlying causes of equipment failures before they result in downtime [5]. Reducing equipment downtime not only lowers NPT but also optimizes maintenance costs. Improved equipment reliability leads to fewer emergency repairs and extended equipment life, thereby contributing to cost savings and operational efficiency.
2. *Optimizing Drilling Parameters*: Inefficient drilling parameters can lead to excessive NPT and higher operational costs. Lean Six Sigma helps in fine-tuning drilling parameters to enhance performance and reduce inefficiencies. The Measure and Analyze phases of DMAIC involve collecting data on drilling parameters and analyzing their impact on performance. By using Six Sigma techniques such as Statistical Process Control (SPC) and Design of Experiments (DOE), drilling parameters can be optimized to improve penetration rates and reduce the frequency of costly adjustments [16]. Optimized drilling parameters result in more efficient drilling operations, reduced NPT, and lower drilling costs. This leads to improved project timelines and overall cost-effectiveness.
3. *Improving Process Efficiency*: Lean principles focus on eliminating waste and improving process efficiency. In offshore drilling, inefficient processes can lead to increased NPT and higher operational costs. Lean techniques such as Value Stream Mapping (VSM) and Kaizen can be employed to streamline drilling operations and eliminate non-value-adding activities [12]. This includes optimizing workflows, reducing delays, and enhancing coordination among various operational teams.

Improved process efficiency reduces NPT by minimizing delays and operational interruptions. This leads to cost optimization through better resource utilization and faster project completion times.

4. *Enhancing Resource Management*: Effective resource management is crucial for minimizing costs and optimizing operations. Lean Six Sigma helps in managing both human and material resources more efficiently. The Define and Measure phases involve assessing resource allocation and utilization. Lean Six Sigma techniques can identify areas of resource wastage and implement strategies for better resource planning and allocation [7]. This includes optimizing crew deployment, managing inventory levels, and improving supply chain logistics. Enhanced resource management reduces operational costs and NPT by ensuring that resources are used effectively and efficiently. It also helps in avoiding overstocking and underutilization, leading to cost savings and operational improvements.
5. *Implementing Predictive Analytics*: Predictive analytics plays a vital role in anticipating and mitigating potential issues that can lead to NPT and increased costs. Lean Six Sigma incorporates data-driven approaches to enhance decision-making and improve operational performance. By integrating data analytics with Lean Six Sigma methodologies, organizations can forecast potential problems and implement preventive measures. Techniques such as Predictive Maintenance Analytics and Machine Learning Algorithms can be utilized to monitor equipment conditions and predict failures before they occur [13]. Predictive analytics reduces NPT and operational costs by addressing issues proactively. This leads to fewer unplanned downtimes, optimized maintenance schedules, and overall cost savings.

5. Conclusion

The implementation of the Lean Sigma framework will lead to significant improvements in both economic and environmental performance. The application of Lean Sigma in the oil and gas industry enhances quality, operational efficiency, and environmental outcomes [2]. The process improves and innovates crude oil processing, thereby resulting in better fuel gas consumption and increased product quality. Several challenges, such as high base sediment and water (BS&W) content in input materials, outdated equipment, and outdated processing methods, initially hindered performance. However, these issues are better addressed using Lean Sigma initiatives, leading to improved product quality, reduced fuel gas usage, and significant cost savings. Additionally, the innovations reduce greenhouse gas emissions, positively impacting both financial performance and the company's environmental image.

Abbreviations

FDP	Field Development Plan
NPT	Non-Productive Time
HSE	Health, Safety, And Environmental
DMAIC	Define, Measure, Analyze, Improve and Control
FMEA	Failure Mode and Effects Analysis
RCA	Root Cause Analysis
SPC	Statistical Process Control
DOE	Design of Experiments
BS&W	Base Sediment and Water
VSM	Value Stream Mapping

Author Contributions

Oboho Eteyen is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Antony, J. (2004). Six Sigma in the UK service organisations: Results from a pilot survey. *Managerial Auditing Journal, 19(8),* 1006-1013.

[2] Balasharmila, R., & Munusamy, L. (2023). Development Of Drilling Non-Productive Time Reduction Framework Using Lean Six Sigma Methodology For Buntal Exploration Wells.

[3] Brenig-Jones, R. (2017). *The Lean Six Sigma guide to doing more with less: Cut costs, reduce waste, and lower your overhead*. McGraw-Hill Education.

[4] Buell, R., & Turnipseed, D. (2004). *Six Sigma: The breakthrough management strategy revolutionizing the world's top corporations*. Crown Business.

[5] Chen, Z., Yang, Q., Ma, D., & Zhang, Y. (2022). Real-time monitoring and prediction of non-productive time during drilling operations using machine learning. *Journal of Petroleum Science and Engineering, 209*, 109-290.

[6] Dale, B. G. (2003). *Managing quality (4th ed.).* Blackwell Publishing.

[7] Emhanna, A. (2018). Investigation into non-productive time (NPT) in the oil and gas industry: Causes and mitigation strategies. *Journal of Petroleum Technology, 70(3),* 58-63.

[8] Goldratt, E. M. (1984). *The goal: A process of ongoing improvement.* North River Press.

[9] Gupta, M., & Boyd, L. H. (2008). Theory of Constraints: A theory for operations management. *International Journal of Operations & Production Management, 28(10),* 991-1012.

[10] Krygier, M., Solarin, A., & Orozova Bekkevold, I. (2020). The impact of geological and non-geological factors on non-productive time in drilling operations. *Energy Policy Review, 45(2),* 102-115.

[11] Langford, D., & Male, S. (2001). *Strategic management in construction (2nd ed.)*. Wiley-Blackwell.

[12] Salah, S., Rahim, A., & Carretero, J. A. (2010). The integration of Six Sigma and lean management. *International Journal of Lean Six Sigma, 1(3),* 249-274.

[13] Smith, R., Hargrove, S., & Dunlap, M. (2021). Technological innovations in drilling: Enhancing efficiency and reducing costs. *Energy Technology Review, 35(4),* 213-227.

[14] Snee, R. D. (2010). Lean Six Sigma—Getting better all the time. *International Journal of Lean Six Sigma, 1(1)*, 9-29.

[15] Womack, J. P., & Jones, D. T. (1996). *Lean Thinking: Banish waste and create wealth in your corporation*. Simon & Schuster.

[16] Zhu, L., Cheng, J., Li, X., & Wang, H. (2021). Advanced analytics for NPT prediction in offshore drilling: A case study using big data approaches. *Energy Exploration & Exploitation, 39(1),* 182-199.