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Review

A Qualitative and Literature-Based Technology Study of Drilling Rig Hoisting System Equipment

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Abstract: Oil and gas energy in Indonesia plays a vital role in driving the country's economy, particularly as a foreign exchange earner and domestic energy supplier. The hoisting system is located on the surface of the rig and works in conjunction with other drilling systems. This study aims to provide an introduction and understanding of the equipment used in hoisting systems in oil and gas drilling activities, enabling students to understand the types of equipment and their uses. This relates to the drilling equipment course, which aims to provide students with a better understanding of the context of practical learning, which is difficult to conduct in the field for direct observation. Therefore, the research method used is a literature review with a qualitative approach to narrate and describe the process of activities carried out in practical learning, starting from the equipment introduction stage, gathering technical information from literature studies, and observing the drilling equipment using sketches and instructional videos of the equipment used in the drilling hoisting system. Based on these observations, students are able to explain and understand the scope of the hoisting system in oil and gas drilling.

Keywords: Equipment; System; Hoisting; Drilling; Qualitative.

1. Introduction

Oil and gas are natural resources that produce energy essential for modern human life, providing numerous benefits in daily activities. Oil and gas energy in Indonesia plays a crucial role in the economy, serving as a source of foreign exchange and as a supplier of domestic energy needs, contributing to the state budget (APBN) revenue and energy sources, particularly fuel.

Jobs in oil and gas companies also encompass several disciplines, including engineering, information technology, health and safety, law, economics, and other activities. The engineering backgrounds required in oil and gas companies are diverse, encompassing areas beyond petroleum science, including electrical engineering, industrial engineering, chemistry, physics, metallurgy, materials engineering, and others. Each discipline plays a crucial role in the development of the oil and gas industry. In the oil and gas drilling industry, the success of an operation is determined not only by drilling equipment technology but also by complex support systems, one of which is the hoisting system.

According to Suhascaryo (2020), rotary drilling equipment technology can be divided into four main systems and two supporting systems. The main system consists of a power system, a lifting system, a rotary system, a circulation system, and a BOP (wild spray prevention) system. The two supporting systems include a cementing system and a priming system [1].

Hoisting system equipment plays a key role in lifting and lowering drill pipe, casing, and other heavy equipment into and out of the wellbore. Without a reliable and safe hoisting system, drilling activities are at risk of delays, equipment damage, and even workplace accidents. The hoisting system is located on the surface of the rig and works in conjunction with the drilling system. Therefore, a thorough understanding of how the hoisting system works is crucial, not only for mechanical design but also for field operations.

Figure 1. Diagram of research method.

The purpose of this paper is to provide a basic introduction to the practical learning of drilling equipment, specifically hoisting systems used in oil and gas drilling activities, both offshore and onshore. Therefore, this paper is a qualitative study, data collected through a literature review. Based on the objectives and results of the activities, this research examines A Qualitative and Literature – Based Technology Study of Drilling Rig Hoisting System Equipment.

2. Related Work

The hoisting system is a system of drilling equipment components that functions to provide sufficient working space for hoisting and lowering drill string and casing equipment into the drill hole during drilling operations.

The hoisting system plays a crucial role, given that it experiences the greatest loads, both vertical and horizontal. Vertical loads originate from the tower, drill string (drill pipe and drill collar), casing string, deadline tension, fast line tension, and block-block tension. Horizontal loads originate from wind and the drill pipe resting on the tower. These loads, in part, are caused by wind, which significantly impacts the hoisting system's load during offshore drilling [2].

Kalapain & Massolo (2022) explained that the hoisting system must be tailored to the drilling activity requirements and the WOWS, as well as the power supply to operate it. Drilling, workover, and well repairs always involve lifting and lowering drill strings, tubing, and casing [3].

At the start of drilling, also known as "spudding in," the first step begins with drilling a large-diameter, shallow hole. The hole created is called a conductor hole, with a depth of 20-60 meters. Then, drilling is carried out so that the hole is lined with a conductor casing and cemented. The conductor casing serves to prevent the top of the wellbore from collapsing and sinking into the well. Then, drilling a smaller diameter hole with a depth of between 100- and 150-meters functions to seal the surface water aquifer, stabilize the top of the well, and provide a connection to prevent wild blowouts from occurring at the wellhead [4].

In previous research, it stated that a drilling rig is a very large offshore facility, consisting of two parts: the platform and the offshore drilling system attached to the platform. One of the main functions of the offshore drilling system is to drill holes on the seabed. This requires several subsystems, including the drill string, which consists of steel pipes and drill bits used to dig the hole, and a lifting system used to raise and lower the drill string in and out of the hole. Semi-submersible rigs can move due to the influence of waves. This horizontal movement of the semi-submersible can be controlled by a mooring system and dynamic positioning, unlike vertical movement. A heave compensation system is needed to keep the drill string stationary and unaffected by heave motion. However, the motion and efficiency of the heave compensation system need to be evaluated through dynamic response analysis before implementing it in offshore drilling operations. This study aims to develop multibody dynamics kernels useful for conducting dynamic response analysis and controlling the heave compensation system on offshore drilling rigs by simulating drilling operations under various wave loads [5].

3. Methodology

Research method according to Bungin, 2003:3. is a scientific way to collect data with a purpose and has a certain use. This scientific method means that the research activity is based on scientific characteristics such as irrational, systematic and empirical [6]. According to Burns & Grove (1993) Qualitative research emphasizes the use of various relevant literature, in this case when and for what purpose the use of the literature and has variations based on the type of qualitative research conducted [7].

According to Y. Afiyanti in her research, she explains the purpose of using literature in qualitative research, namely, to place the findings of previous studies in the context of various findings that have just been discovered, however, this does not mean conducting in-depth confirmation of the findings of previous research [8]. Several other qualitative researchers argue that literature searches made at the beginning of the research will help in providing direction or focus for the research being carried out [9]. According to Rahmani, Murhayati, and I. Kholis (2025), The qualitative research focuses on understanding in-depth phenomena through the perspectives of the subjects involved in the research. Data analysis plays a crucial role in generating valid and meaningful interpretations [10].

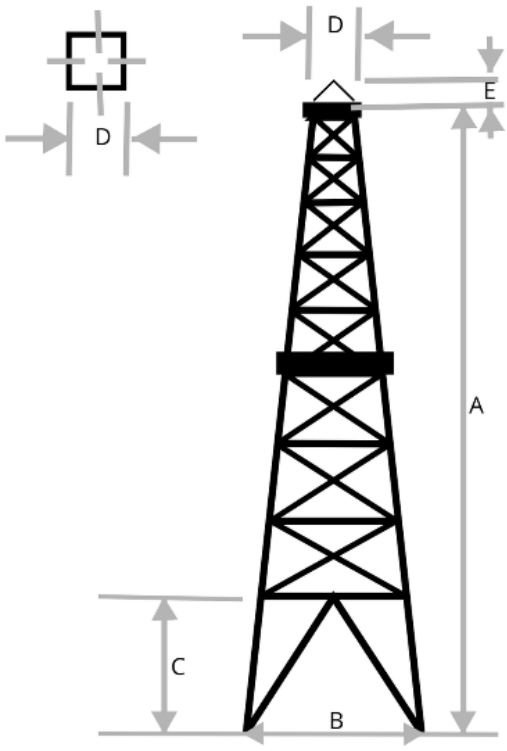

Figure 2. Standard Derrick Tolerance Drawing.

Qualitative research is important so that students can understand the relationship between theory and applied applications in the field, and to be able to identify potential technical problems before damage or accidents occur [10].

The type of research used is research using a qualitative descriptive approach and based on literature study. The qualitative approach was chosen to systematically describe the process of observation activities, starting from the introduction stage of the tool, collecting information from the literature study obtained to interpret the results of research on equipment technology in the drilling lifting system so that an understanding of the work benefits and functions of the hoisting system equipment components is obtained. The diagram of research method is in Figure 1.

From Figure 1, the research began with literature study. It was study about drilling rig hoisting system equipment; from the study the writer decides the main object and topic of the research and also did identification from literature study. The data collected with qualitative methods about hoisting systems. After that, I did the analysis and got result from the method. The conclusion was the last step in the result of research.

4. Results

The offshore industry can be described as a technology-driven industry. Technology within the industry has been used in other industries, including the space program. These technological advances enable exploration into more remote waters. These advances can be traced to everything from platform design to the use of remotely operated vehicles, which are useful in maintaining subsea systems [11].

A technical and operational understanding of each piece of equipment used in oil and gas drilling, including its operating principles, routine maintenance, and compliance with safety standards, is a must for field workers. Regular inspections and proper maintenance of equipment will extend its lifespan, prevent system failures, and prevent workplace accidents that could negatively impact both financial and personal safety.

The hoisting system is a crucial parameter during drilling operations, specifically when lifting and lowering drill strings, casing strings, tubing, and other supporting equipment. According to R. J. Lei, *et al* (2017), The mine hoist system is an important part of mining construction equipment and plays a vital role in resource exploitation. The hoist system is a key link in the underground and underground, accommodating transport personnel and improving the transportation of ore, scrap metal, and underground equipment. During this lifting process, the swing of the hoist cage can cause discomfort to passengers and even affect the normal operation of the hoisting machinery, which can lead to major accidents [12]. The hoisting system operates mechanically and hydraulically and involves critical components such as the drawworks, crown block, traveling block, hook, and drilling line.

The hoisting system is the center of vertical activity on the rig and therefore must be designed to handle very large loads to meet safety and efficiency requirements. Essential equipment components of the hoisting system include: The derrick, which serves as the main vertical structure on the drilling rig, supports the crown block and supports all lifting loads during drilling operations. There are two general types of derricks: permanent and portable masts. ASME defines this hoisting system as an equipment that includes a mast or equivalent component supported by support, with or without a boom, for use with a winching mechanism and operating rope.

4.1. Derrick

ASME B30.6 identifies eight commonly used derrick types and provides guidance on the construction, installation, technical operation, inspection, testing, and maintenance of these derricks [13].

The standard derrick tolerances on a drilling rig can be shown in Figure 2 [14].

- A, Vertical distance from the top of the base plate to the bottom of the Crown Block support beam, ± 6 in.
- B, Distance from heel to heel of adjacent feet, ± 5 in.
- C, Window opening measured in a clear space parallel to the centerline of the tower side from the top of the base plate, + 3 ft. 6 in.

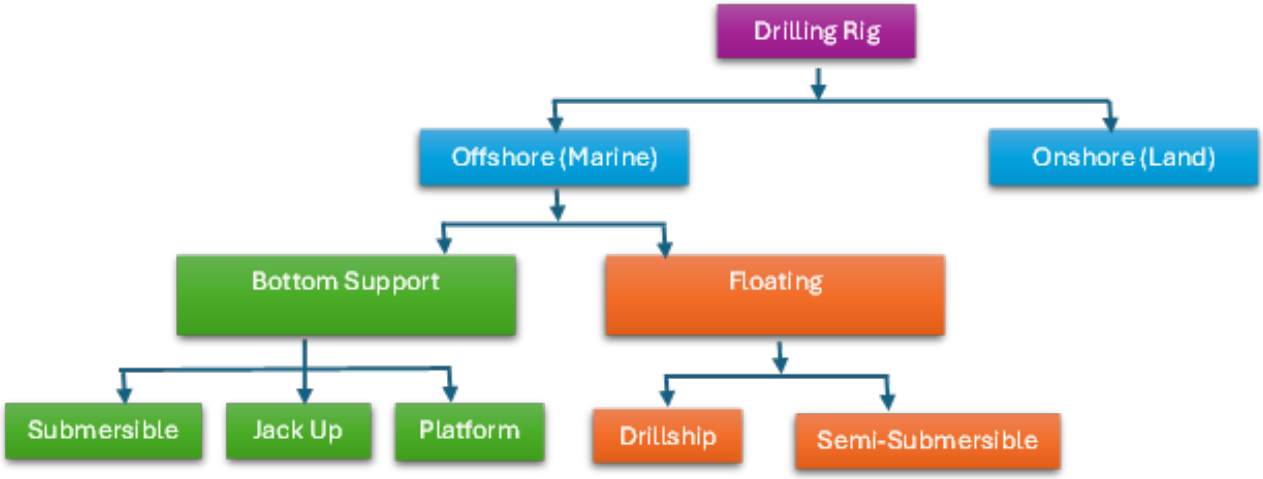

Figure 3. Classification drilling rig based on the well location.

- D, Smallest clear dimension at the top of the derrick that will restrict the passage of the crown block, ± 2 in.
- E, Clearance between the horizontal header of the gin mast and the top of the crown support beam, ± 6 in.

There are other types of drilling rigs related to those used for drilling in offshore or marine areas. Land-based rigs can be classified according to their mobility and drilling depth.

Offshore rigs are classified based on their mobility and depth to the seabed. So based on the classification, the types of offshore drilling rig platforms are platforms supported below sea level or known as Bottom-Supported Units and Floating Platforms or Floating Units.

These floating rigs are categorized as semisubmersibles and drillships, while barges, jack ups, and platform rigs are categorized as rigs supported on the seabed [15]. The drilling rig have classification in drilling rig [16], it can be seen in Figure 3.

4.2. Drawwork

The drawworks equipment in offshore drilling systems is the driving force behind the hoisting system. The drawworks is a large drum powered by an electric or diesel motor. The main function of the drawworks is to roll and unroll the drilling rope, which is a large diameter wire rope that is carried out in a controlled manner [17]. It is wrapped around a steel wire rope called a drilling line, which is used to pull or extend the load. This equipment is also equipped with a precision braking system that controls the load so that it can be operated safely during technical operations such as raising and lowering loads.

Drawworks equipment components include the main drum, drive motor, clutch, main brake, and auxiliary brake. The drawworks brake system consists of two types: the main brake and the auxiliary brake. The main brake is a mechanical brake mounted on the drum flange or a hydraulic or mechanical disc brake system. The auxiliary brake can be a hydrodynamic brake, electromagnetic brake, or magnetic particle brake. The types of brakes used include mechanical brakes and pneumatic or hydrometric brakes. For safe operation, an automatic locking system is required to prevent damage when heavy loads are lowered.

The hoisting system includes block components, namely the crown block and the traveling block. A crown block is a collection of static pulleys located at the top of the derrick. This crown block acts as a guide point for the drilling line and distributes the load to the rig structure. This fixed position ensures stability and safety during lifting operations. In this equipment familiarization activity, understanding the crown block's function as a fulcrum demonstrates how the load is distributed structurally.

4.3. Wire Rope (Drilling Line)

Wire rope, also known as drilling line, is a rope made of steel material wound between the crown block and traveling block. Drilling line is generally made of steel wire twisted from several strands in a helical pattern. The construction of this pattern provides the necessary strength to withstand pressure and abrasion during the drilling process. Drilling line must be able to withstand large heavy loads from drill strings and other drilling tools without experiencing damage or failure. This drilling line not only functions as a medium for connecting loads but also to create mechanical advantages through a pulley system. Periodic inspections are useful for maintaining the safety and performance of the steel rope. Its use is for lifting loads. The decreased ability of steel rope to withstand loads is usually caused by several important factors such as abrasion, corrosion of the steel rope, and can also be due to changes in the structure of the drilling line/wire rope itself.

According to Rudenko (1992) in conducting an analysis of the strength of wire rope, it consists of factors of hourly lifting capacity, maximum tensile stress on the rope, breaking strength of the rope, maximum permissible

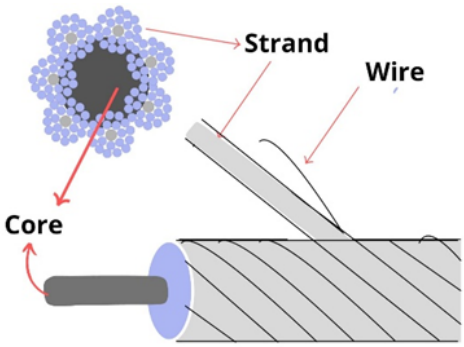

Figure 4. Wire rope Construction.

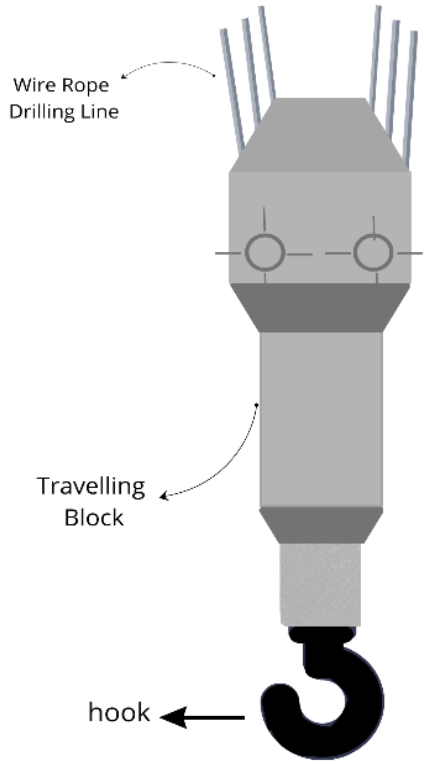

Figure 5. Travelling block and hook drilling rig.

tension of the steel rope, tension of the rope loaded on the curved part due to tension and bending, cross-sectional area of the steel rope, age/lifetime of the steel rope, tensile stress that occurs on the steel rope, the number of repeated bends of the steel rope [18]. Sometimes it happens that the steel rope or wire rope on the hoist crane does not match the time specified by the specifications so that the rope breaks or breaks, so for this case it is necessary to take into account the strength that can be lifted by this steel rope so that it does not break or break easily in a short time. According to Klinke (2008), all rigging equipment is susceptible to wear, misuse, and overloading, which can reduce its rated capacity. OSHA and ASME standards require that rigging equipment be periodically inspected to determine its condition [19].

Kholis (2014) outlined the assumption that wire rope is an acceptable machine because it has several moving parts that support and dynamically distribute loads to perform the work. One of the advantages of wire rope is that it can withstand heavy loads while remaining flexible [20].

The selected drilling line must take the following factors into account: First, the wire rope diameter must match the sheave groove size of the crown, drum, and traveling block; second, the twist direction (lay) must match the drum; third, the appropriate core type for the drilling line is IWRC (Independent Wire Rope Core); fourth, the steel grade of the wire rope used must meet API recommendations, namely IPS or EIPS; and fifth, the selected drilling line length must be the minimum required length, plus a reserve for shifting and/or cutting for optimal performance [21]. There are three main components in wire rope construction, namely wire, strand and core [22] in Figure 4.

4.4. Top Drive

Top drive or Kelly drive equipment in a hoisting system complements the core hoisting system, but the presence of a top drive or Kelly drive attached to the hook indicates integration between the two: hoisting and rotary systems in the drilling rig ensures that the vertical movements of these two systems are interconnected during drilling operations.

The components that are involved in a top drive system namely: Elevator, Bail Assembly, Grabber Assembly, Saver Sub, Stabbing Valve, Tilt Assembly, Pipe Handler Assembly, Load Nut, Mainframe Assembly, Quill, Extend Frame, Swivel Sub, Torque Bushing, Optional Swivel, Torque Track [23].

4.5. Traveling block and Hook

The hook component in the hoisting system serves as a connection between the traveling block and other drilling equipment. The hook must have a very high lifting capacity and be flexible in movement. The hook connection is crucial to prevent equipment from falling. Several factors influence the hook load, including drill string weight, which depends on the length, pipe size, and material of the drill pipe, collars, and other components. Furthermore, the BHA weight depends on the accompanying tools and equipment, such as stabilizers, reamers, and mud motors. Additional equipment suspended from the hook, such as drilling mud pumps or other surface equipment, can also be considered.

In the general context of industry and construction, such as drilling rigs, hoisting systems can be classified based on their drive mechanism: manual hoists, electric hoists, pneumatic hoists, and hydraulic hoists. Manual hoists require human power to operate using a hand chain or lever hoist. Manual hoists are simple, portable, and require no external power source. They have limited hoisting capacity and speed. Examples of this equipment include chain blocks and lever blocks.

Electric hoists are driven by electric motors. They move faster and have a greater lifting capacity than manual hoists. Electric hoists require an electrical power source. Electric chain hoists use chains as the lifting medium and are relatively easy to maintain. Electric wire rope hoists use steel wire rope as the lifting medium. Electric hoists can lift heavier loads and reach higher lifting heights. Next are Electric Belt Hoists, which use belts as the lifting medium and are suitable for environments requiring high cleanliness. The hook is equipped with a safety hook that serves as a swivel and connecting ears on both sides for mounting the elevator connector. The hook also serves as a drilling that prevents it from rotating with the Kelly [24]. The travelling block and hook can see in Figure 5.

Pneumatic hoists are components driven by compressed air. These hoists are resistant to dusty, vaporous, and extreme temperature conditions, and are explosion-proof. Their lifting speed can be adjusted using air controls. Hydraulic hoists are lifting components that use hydraulic fluid pressure to lift loads. These compo-nents can lift very heavy loads with a relatively small motor. Their movements are smooth and controlled.

5. Conclusion

Referring to the discussion above, the drilling hoisting system consists of several important components are the derrick, block (crown block and traveling block), drawworks, drilling line, hook, kelly, and elevator. These components work in an integrated manner to connect and disconnect the drilling string in accordance with established standards and international standards as a reference in the design and operation of hoisting system equipment, which is useful for ensuring safety and reliability in drilling operations.

The hoisting system in drilling functions to lift and lower the drill string, casing, and other subsurface equipment into or out of the wellbore, provide vertical working space for connecting or disconnecting the pipe, and accommodate the enormous vertical loads generated by the pipe string, derrick, and other equipment.

6. Declarations

6.1. Author Contributions

Rachmasari Pramita Wardhani: Conceptualization, Methodology, Software, Validation, Formal Analysis, Data Collection, Writing – original draft, Writing – review & editing, Visualization, Supervision; **Cristo Nathanael Rayhan Simanjuntak:** Writing – original draft; **Abdul Gafar Karim:** Writing & review.

6.2. Institutional Review Board Statement

Not applicable.

6.3. Informed Consent Statement

Not applicable.

6.4. Data Availability Statement

The data that supports the findings of this study is based on literature studies, geometric Canva.

6.5. Acknowledgment

This work is an independent work. I would like to express my gratitude to my fellow authors, both lecturers and student, for the collaboration in writing and compiling this scientific work.

6.6. Conflicts of Interest

The authors declare no conflicts of interest.

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