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Influence of mechanical factors on the performance and aging process of oil pump jack

Wpływ czynników mechanicznych na wydajność i proces starzenia się kiwona

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ABSTRACT: The paper discusses the influence of mechanical factors on the performance and aging process of rocking machines, specifically focusing on oilfield equipment such as the downhole rod pump jack. The authors emphasize the importance of analyzing the condition and aging process of oilfield equipment to ensure reliability, safety, and efficiency in oil production processes. The mechanical factors discussed in the paper include vibrations, loads, wear, and corrosion. Vibrations can be caused by improper balance, bearing failures, or other factors, and they have a negative impact on equipment performance and can lead to breakdowns. High mechanical loads associated with raising and lowering sucker rods can cause wear and damage to the pump jack. Operating in harsh environments with sand, abrasive particles, or chemicals can also cause wear on surfaces and equipment parts. Corrosion of metal components can occur due to moisture, chemical attack, or improper storage and maintenance, leading to deterioration and breakage of equipment. The consequences of these mechanical factors on the aging of an oil pump jack include accelerated aging, decreased performance, and an increased risk of accidents. Continuous exposure to vibration, stress, wear, and corrosion accelerates the aging process, resulting in deterioration and reduced equipment life. Damage and breakdowns caused by mechanical factors lead to decreased efficiency, negatively impacting oil production processes. Moreover, insufficient maintenance and failure to address mechanical influences increase the risk of accidents, downtime, and damage to other parts of the manufacturing process. To assess the health and aging status of an oil pump jack, various analysis and diagnostic methods are used, including visual inspection, strength testing, monitoring of parameters, and non-destructive testing. Visual inspection helps identify visible damage, wear, and defects. Strength testing evaluates the reliability of pump jack parts and identifies potential issues. Monitoring parameters like vibrations, temperature, and pressure allows for detecting deviations from normal operation and preventing breakdowns. Non-destructive testing methods such as ultrasonic testing, magnetic particle testing, and radiography help identify hidden defects and damage. The authors recommend several strategies to maintain the reliability and efficiency of an oil pump jack. These strategies include implementing a preventive maintenance program with regular inspection, testing, and parts replacement based on manufacturer's recommendations and equipment condition analysis. Determining optimal service and part replacement intervals based on historical data, monitoring results, and manufacturer's recommendations is crucial. Additionally, utilizing more durable materials, anti-corrosion coatings, improved designs, and technologies can increase equipment resistance to mechanical stress and improve performance. The paper also describes the device and components of a pump jack, such as the installation base, platform, balancer, electric motor, crank, connecting rod, and control station. It emphasizes the importance of considering various characteristics when selecting and evaluating the effectiveness of a pump jack, including working load, maximum plunger stroke, reducer dimensions, output torque, and swing frequency. The kinematics of the pump jack drive system are discussed, highlighting the need for reconfiguration to adapt to changing operating conditions and optimize oil production performance. Overall, the paper emphasizes the importance of analyzing mechanical factors, managing the aging process, and implementing maintenance strategies to ensure the reliable and efficient operation of oilfield equipment, specifically the pump jack used in oil production processes.

Key words: oil pump jack, vibration, wear, load, corrosion, swing frequency, mechanical factors, deformation and fracture.

STRESZCZENIE: W artykule omówiono wpływ czynników mechanicznych na wydajność i proces starzenia się kiwonów, koncentrując się na urządzeniach do eksploatacji złóż ropy naftowej. Autorzy podkreślają znaczenie analizy stanu i procesu starzenia się sprzętu naftowego dla zapewnienia niezawodności, bezpieczeństwa i wydajności procesów produkcji ropy naftowej. Czynniki mechaniczne omówione w artykule obejmują drgania, obciążenia, zużycie i korozję. Drgania mogą być wywołane przez nieodpowiednie zbalansowanie, usterki łożysk lub inne czynniki i mają negatywny wpływ na wydajność sprzętu oraz mogą prowadzić do awarii. Wysokie obciążenia mechaniczne powiązane z podnoszeniem i opuszczaniem żerdzi pompowych mogą powodować zużycie i uszkodzenie kiwona. Praca w trudnych środowiskach z piaskiem, cząstkami ścierającymi lub chemikaliami może także skutkować zużyciem powierzchni i części sprzętu. Korozja komponentów metalowych może wystąpić w związku z wilgocią, agresywnością chemiczną lub nieodpowiednim przechowywaniem i konserwacją i doprowadzić do degradacji i uszkodzeń sprzętu. Konsekwencje tych czynników mechanicznych

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względem starzenia się kiwona obejmują przyspieszone starzenie, zmniejszoną wydajność i zwiększone ryzyko wypadków. Stałe narażenie na drgania, naprężenie, zużycie i korozję przyspiesza proces starzenia, powodując degradację i zmniejszenie żywotności sprzętu. Uszkodzenia i awarie wywołane przez czynniki mechaniczne prowadzą do zmniejszenia wydajności, wpływając negatywnie na procesy produkcji ropy naftowej. Ponadto niewystarczająca konserwacja i brak uwzględnienia wpływów mechanicznych zwiększają ryzyko wypadków, przestoju i uszkodzenia innych elementów procesu produkcyjnego. Aby ocenić stan i status starzenia się kiwona, stosuje się różne analizy i metody diagnostyczne, w tym inspekcję wizualną, próby wytrzymałościowe, monitorowanie parametrów i próby nieniszczące. Inspekcja wizualna pomaga zidentyfikować widoczne uszkodzenia, zużycie i defekty. Próby wytrzymałościowe oceniają niezawodność części kiwona i identyfikują potencjalne problemy. Monitorowanie parametrów takich jak drgania, temperatura i ciśnienie pozwala wykryć odchylenia od normalnej pracy i zapobiec awariom. Metody prób nieniszczących, takie jak badania ultradźwiękowe, badania magnetyczno-proszkowe i radiografia, pomagają odnaleźć ukryte defekty i uszkodzenia. Autorzy rekomendują kilka strategii dla zachowania niezawodności i wydajności kiwona. Strategie te obejmują wdrożenie zapobiegawczego programu konserwacji z regularnymi przeglądami, testami i wymianą części na podstawie rekomendacji producenta i analizy stanu sprzętu. Kluczowe jest ustalenie optymalnych przedziałów serwisowania i wymiany części, opierając się na danych historycznych, wynikach monitoringu i rekomendacjach producenta. Dodatkowo stosowanie wytrzymalszych materiałów, powłok antykorozyjnych, ulepszonych konstrukcji i technologii może zwiększyć wytrzymałość sprzętu na naprężenia mechaniczne i poprawić wydajność. W artykule opisano także urządzenia i komponenty kiwona, takie jak podstawa instalacyjna, platforma, wahacz, silnik elektryczny, korba, żerdź łącząca i stanowisko sterowania. Podkreślono znaczenie uwzględnienia różnych cech podczas wyboru i oceny wydajności kiwona, w tym obciążenia roboczego, maksymalnego suwu tłoka, wymiarów reduktora, wyjściowego momentu obrotowego i częstotliwości ruchu wahadłowego. Omówiona została kinematyka systemu napędowego kiwona, z podkreśleniem potrzeby rekonfiguracji w celu przystosowania się do zmiennych warunków pracy i optymalizacji wydajności produkcji ropy naftowej. Ogólnie rzecz biorąc, w artykule podkreślono znaczenie analizy czynników mechanicznych, zarządzania procesem starzenia i wdrażania strategii konserwacji dla zapewnienia niezawodnej i wydajnej pracy sprzętu na złożach ropy naftowej, a konkretnie kiwona stosowanego w procesach produkcji ropy naftowej.

Słowa kluczowe: kiwon, drgania, zużycie, obciążenie, korozja, częstotliwość wychylenia, czynniki mechaniczne, odkształcenia i spękania.

Introduction

Oilfield equipment plays a key role in the oil industry, providing for the extraction, transportation and processing of petroleum products. During operation, it is subjected to various influences, which eventually lead to aging and a decrease in its performance. Therefore, the analysis of the state and aging process of oilfield equipment, including the downhole rod pump jack, is an important task to ensure the reliability and efficiency of oil production processes. Reliable equipment performance is also a key factor in ensuring the safety and efficiency of oil operations.

Analysis of the technical condition of oilfield equipment allows you to determine its current state, identify potential problems and prevent emergencies. This analysis includes evaluation of various parameters such as equipment wear, leaks, corrosion, cracks and other defects. Various methods can be used to perform the analysis, including visual inspection, parameter measurements, non-destructive testing, and diagnostic tests.

The aging process of oilfield equipment is associated with the accumulation of damage and wear of its components as a result of operating under high loads, aggressive environments and mechanical impacts. This can lead to a decrease in the efficiency and reliability of equipment, as well as an increased risk of accidents and downtime in the oil production process (Smith and Moubray, 2002; Moubray, 2010; Dhillon, 2012, Smith, 2016).

Various strategies can be applied to manage the aging process and maintain the health of oilfield equipment. Important measures are regular maintenance and replacement of worn or damaged components (Nowlan and Heap, 1978; Vachtsevanos et al., 2006; Asian Development Bank, 2008; Kennedy, 2008). In addition, the use of preventive control methods, such as equipment monitoring, lubricant analysis, strength testing and non-destructive testing, allows identifying problems at an early stage and taking measures to prevent them (ISO 14224:2016).

Analysis of the state and aging process of oilfield equipment, including the downhole rod pump jack, is an important task to ensure the reliability, safety and efficiency of oil operations (Figure 1). Regular maintenance, application of preventive control methods and replacement of worn components help to keep the equipment working and prevent accidents and downtime in the oil production process.

The aim of this paper is to review mechanical factors that affect the performance of pump jacks and discuss strategies to monitor the equipment condition during its use.

We consider the following mechanical factors, which include:

- *Vibrations*: Improper balance, bearing failures, and other causes can cause vibrations that adversely affect equipment performance and can lead to breakdowns;
- *Loads*: The high mechanical loads associated with raising and lowering sucker rods can cause wear and damage to a pump jack;

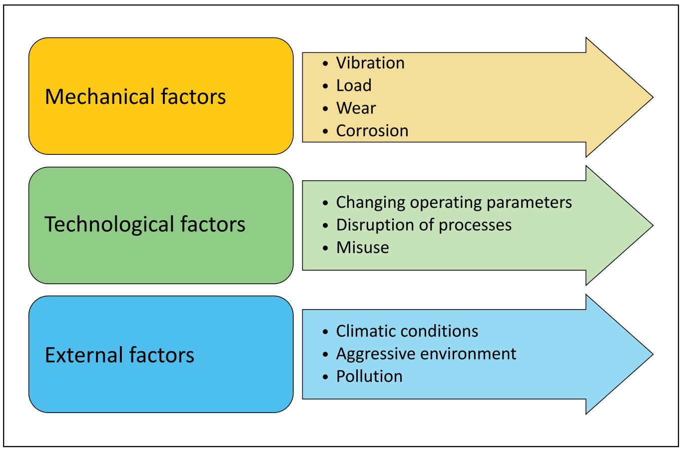

Figure 1. Classification of factors influencing the aging process of a pump jack

Rysunek 1. Klasyfikacja czynników wpływających na proces starzenia kiwona

- *Wear*: Operating a pump jack in harsh environments with high levels of sand, abrasive particles, or chemicals can cause wear on surfaces and equipment parts;
- *Corrosion*: The presence of moisture, chemical attack, or improper storage and maintenance of the equipment can cause corrosion of its metal components, which can eventually lead to breakage and deterioration in performance.

The impact of mechanical factors on the aging of an oil pump jack can have the following consequences:

- Accelerated Aging: Continuous exposure to vibration, stress, wear and corrosion can accelerate the aging process of equipment, causing deterioration and reduced life;
- Decreased performance: damage and breakdowns caused by mechanical factors can lead to a decrease in the efficiency of a pump jack, which negatively affects the processes of oil production and rocking;
- Risk of accidents: Insufficient maintenance and failure to prevent mechanical influences can increase the risk of accidents that can lead to downtime and damage to other parts of the manufacturing process.

Various analysis and diagnostic methods are used to determine the health and aging status of an oil pump jack, including:

- Visual Inspection: Inspection of the equipment reveals visible damage, wear and other defects;
- Strength Testing: Conducting strength testing allows you to evaluate the reliability of pump jack parts and identify possible problems;
- Monitoring of parameters: monitoring of vibrations, temperature, pressure and other parameters of the equipment operation allows you to detect deviations from the norm and prevent possible breakdowns;
- Non-destructive testing: The use of non-destructive testing methods such as ultrasonic testing, magnetic particle testing and radiography helps to identify hidden defects and damage.

The following maintenance and parts replacement strategies are recommended to keep oil rocking rigs running:

- Developing a preventive maintenance program: creating a regular maintenance schedule, including inspection, testing and replacement of parts in accordance with the manufacturer's recommendations and the results of analyses of the condition of the equipment;
- Determining optimal service and part replacement intervals: determine the optimal timing for replacing worn or highly stressed parts based on historical data, manufacturer's recommendations, and equipment monitoring results;
- Using alternative materials and technologies: the use of more durable materials, anti-corrosion coatings, improved designs and technologies can increase the resistance of equipment to mechanical stress and improve its performance.

These measures will help maintain the reliability and efficiency of oil pump jacks, reduce the risk of breakdowns and accidents, and extend their service life (Mobley, 2002; Reikard, 2005; Bloch and Geithner, 2017).

In oil production from great depths, special rocking equipment is used, which is called a downhole rod pump jack (DRPJ). A DRPJ consist of plunger-type pumps, a drive installed on the surface of the earth above the wells, and a control system with which the operator controls the production process.

DRPJs play an indispensable role in the intensive development of deep oil fields. They provide lifting of oil from wells with the help of plunger pumps. A surface-mounted actuator transfers mechanical energy to plungers that create pressure and help lift the oil up. The production process is controlled by the operator using the pump unit control system. This process is carried out in a cyclic mode, where the plunger, using a converting mechanism – a pump jack – lifts the liquid from the well, and then lowers it again for the next cycle.

Pump jacks are subjected to significant mechanical stress during operation. They have to cope with the high pressure and drag forces as the oil rises. Therefore, the reliability and durability of the components of a rocking pump jack is extremely important. To ensure the reliable operation of pump jacks, regular maintenance and monitoring of the condition of the equipment is necessary. This includes checking and replacing worn parts, monitoring vibrations, temperature and other operating parameters.

Well drilling depths typically reach several thousand metres, but the most common oil horizons are at depths of approximately 1500 metres or more. Some wells reach depths of up to 4000 metres, but these are already exceptional cases.

The principle of operation of the plunger pump of the pump jack is based on its reciprocating movement under the

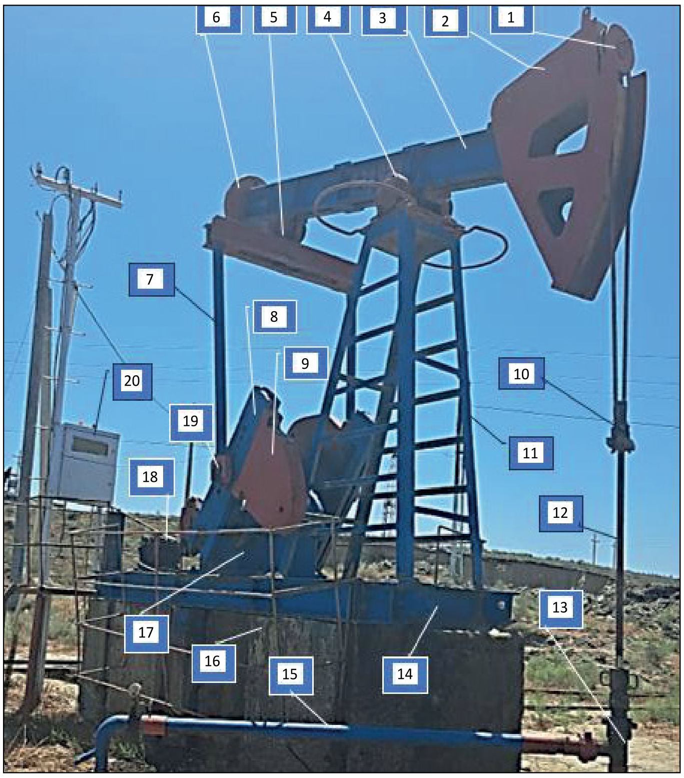

Figure 2. General view of the converting mechanism – pump jack: 1 – block for rope suspension; 2 – the head of the balancer; 3 – balancer; 4 – support; 5 – traverse; 6 – equalizing weight; 7 - connecting rod; 8 – crank; 9 – counterweight; 10 – suspension point of the rod string; 11 – rack; 12 – polished stem; 13 – tee; 14 – frame; 15 – flow line; 16 – concrete foundation; 17 – reducer; 18 – electric motor with V-belt transmission; 19 – brake; 20 – control station

Rysunek 2. Widok ogólny mechanizmu przekazywania kiwona: 1 – blok dla zawieszenia liny; 2 – głowica wahacza; 3 – wahacz; 4 – podpora; 5 – poprzeczka; 6 – wyważenie wahaczowe; 7 – żerdź łącząca; 8 – korba; 9 – przeciwwaga; 10 – punkt zawieszenia kolumny żerdzi; 11 – stojak; 12 – drążek polerowany; 13 – trójnik; 14 – rama; 15 – linia przepływu; 16 – fundament betonowy; 17 – reduktor; 18 – silnik elektryczny z przekładnią z paskiem klinowym; 19 – hamulec; 20 – stacja kontrolna

20 – stacja kontrolna

influence of the rocking mechanism, resembling a swing (Figure 2). This makes it possible to effectively concentrate the oil resource at the well filter and ensure the efficiency of the production process.

The pump jack is designed to minimize the wear of its components and is designed for reliable operation over a long service life (Aliverdizade et al., 1959; Namillion).

The device of the pump jack unit begins with the installation base, which is a concrete base or foundation (16). There is a platform with an operator's cab and a control station (20) on the base. The main element of the pump jack is a massive balancer (3) that balances the head with a rope suspension (1, 2, 10). The power drive of the machine is a powerful electric motor (18), which transmits the force to the balancer through a gearbox (17). Usually, the electric motor is placed on the platform, but sometimes it can be located under it.

Through the crank (8) with the connecting rod (7), the electric motor acts on the balance bar (3), converting the rotation of the motor shaft into a cyclic translational motion of the elements of the deep pump. Thus, the rocking chair creates an up-and-down movement for oil production from the well.

The control station of the pump jack is usually made in the form of a box-shaped unit and contains all the necessary electrical equipment of the complex.

Next to the control relay is a manual type mechanical brake (19) which is used to stop and lock the movement of the machine.

In general, the pump jack unit includes an installation base, a platform, a balancer, an electric motor with a gearbox, a crank with a connecting rod, a head with a rope suspension and a control station with the necessary equipment. The interaction of these elements ensures the operation of the pump jack in the process of oil production.

The main characteristics of a pump jack that should be considered when choosing and evaluating their effectiveness include:

1. Working load on the piston rod (12): this parameter indicates the maximum force with which the machine can lift the plunger pump rod. The choice of machine should be based on the required load to ensure efficient operation under given conditions.
2. Maximum plunger stroke: this is the distance that the pump plunger or the suspension point of the polished rod (10) of the pump jack can rise. It is important for determining the volume of oil that can be pumped out in one cycle of the machine.
3. Reducer dimensions (17): Reducer dimensions may vary depending on the pump jack model and manufacturer. It is important to consider the dimensions when planning the installation of equipment in the field and during its transportation.
4. The amount of output torque: torque indicates the force with which the gearbox transmits rotation from the electric motor to the balancer of the machine. This is an important parameter that determines the performance of the machine under a given load.
5. Swing frequency: This parameter determines the speed and rhythm of the pump jack. The frequency of rocking should be optimal to ensure efficient lifting of oil from the well.

Another important aspect is the power of the electric motor. For pump jacks designed to operate rocking stations, a 25 kW electric motor is usually sufficient. You should also consider the type of belts used to transmit rotation, the diameters of the belt pulleys and the design of the braking mechanism.

The size and dimensions of the equipment also play an important role in choosing a pump jack. They can affect the ability to install equipment in confined spaces and transport it over long distances in different conditions.

All these characteristics should be analyzed and compared with the requirements of a particular oil field in order to select the most suitable pump jack for optimal and safe operation.

The brake mechanism of a pump jack usually consists of two shoes: right and left. This mechanism is designed to fix the machine in the desired position when it stops. When the brake is activated, the pads press against a particular surface or disc, creating friction and preventing the machine from rotating or moving.

The kinematics of the pump jack drive system in oil production is designed in such a way as to ensure the optimal rhythm of movement of the machine head and crank (Figure 3). This driving mode can be easily reconfigured depending on requirements and operating conditions.

The drive system provides a cyclic reciprocating movement of the machine head and crank, which is transmitted to the plunger pump. The optimal movement rhythm is important for efficient oil recovery from the well. By changing drive parameters such as motor speed or gear settings, the speed and range of movement of the machine head and crank can be controlled.

Reconfiguration of the pump jack may be necessary when operating conditions change, such as well depth, oil properties, or production requirements. The operator can adjust the drive parameters to adapt the unit to new conditions and ensure optimum oil production performance.

It is important to note that reconfiguration of the pump jack operation mode must be carried out taking into account the safety and correct operation of the entire system. Any changes to the kinematics and parameters of the drive must be carried out in accordance with the manufacturer's recommendations and safety standards.

Thus, the flexibility and reconfigurability of the kinematics of the pump jack drive system in oil production plays an important role in ensuring efficiency and adapting work to different conditions and requirements.

It is known that in order to extract more oil from the reservoir, it is necessary to choose the right combination of pump jack operating parameters. The performance depends on the main parameters, such as piston stroke, cylinder diameter, the number of swings of the balancer per minute and others. Therefore, specific kinematic diagrams can be obtained for each combination (Janahmadov et al., 1999). Kinematic diagrams of the suspension point for one combination are shown in Figure 4.

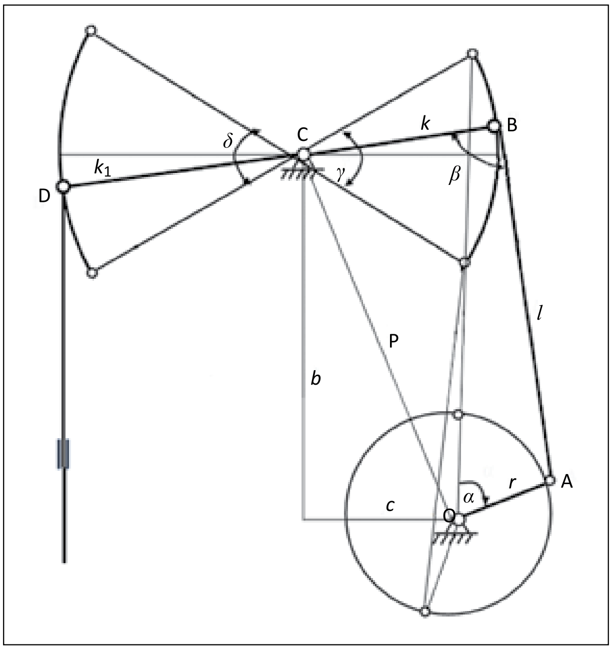

Figure 3. Kinematic diagram of the transforming mechanism – pump jack: k_1, k – front and rear shoulders of the balancer; l – the length of the connecting rod; r – the length of the wheel arm; b, c – coordinates of O support; p – polar distance; α – rotation angle of the wheel arm; β – pressure angle between the balancer and the connecting rod; δ, γ – turning angles of the front and rear shoulders of the balancer; D – suspension point

Rysunek 3. Diagram kinematyczny mechanizmu przenoszenia – kiwona: k_1, k – przednie i tylne ramiona wahacza; l – długość żerdzi łączącej; r – długość ramienia koła; b, c – współrzędne podpory O; p – odległość biegunowa; α – kąt obrotu ramienia koła; β – kąt nacisku między wahaczem i żerdzią łączącą; δ, γ – kąty obrotu przednich i tylnych ramion wahacza; D – punkt zawieszenia

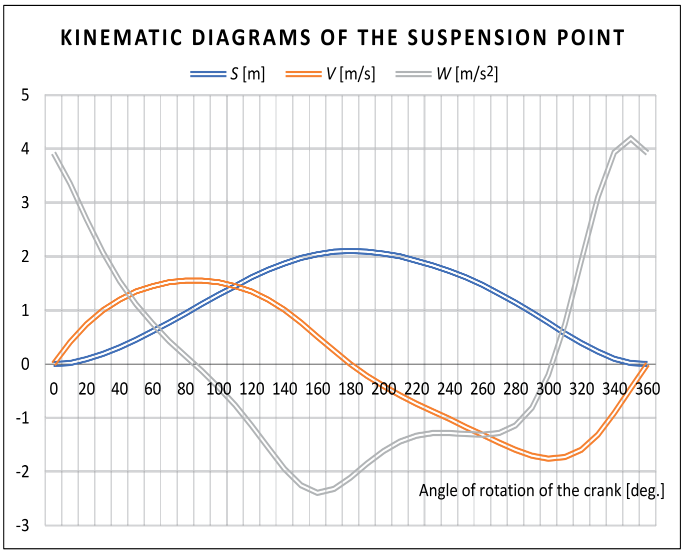

Figure 4. Typical kinematic diagrams of the suspension point where S, V, W are the displacement [m], velocity [m/s] and acceleration [m/s^2] of the suspension point

Rysunek 4. Typowe diagramy kinematyczne punktu zawieszenia, gdzie S, V i W to przemieszczenie [m], prędkość [m/s] i przyspieszenie [m/s^2] punktu zawieszenia

Solution of the problem and discussion of the results

The concept of condition and aging of oilfield equipment:

- The performance of oilfield equipment is determined by its ability to perform the specified functions in accordance with the requirements of oil production and refining processes. Operable equipment ensures the efficiency and safety of oil production and refining processes;
- Aging of equipment is a gradual accumulation of degradation changes, which over time lead to a decrease in its performance.

However, during operation, oilfield equipment is subjected to various influences, which eventually lead to its aging. The aging process is characterized by the gradual accumulation of degradation changes that affect the performance of the equipment. These changes can be caused by mechanical factors such as vibration, stress, and corrosion, as well as process factors, including changing operating parameters, process disturbances, and improper operation.

The aging of oilfield equipment can lead to a decrease in its productivity, an increase in the risk of accidents, as well as an increase in maintenance and repair costs. Therefore, analysis of the condition and the aging process of equipment is important to ensure its reliable and efficient operation, as well as to plan preventive maintenance and replacement of worn components.

As part of the analysis, we will study the impact of various mechanical factors such as vibrations, loads, wear and corrosion on oilfield equipment. Consider the main causes of equipment damage and breakdowns, as well as the methods and technologies used to prevent and manage them.

Mechanical factors have a significant impact on the performance and aging process of the pump jack. Consider the main mechanical factors that can cause equipment damage and breakdown:

Vibrations: Vibrations can occur due to uneven operation of the motor, pump, and due to incorrect installation or imbalance of equipment components. Constant vibrations can cause destruction of materials, as well as cracks, which leads to a decrease in the strength and performance of equipment.

Vibration can have a negative effect on the aging of the pump jack, as it puts extra stress on its components and increases the risk of damage and wear. Here are some ways in which vibration can affect the aging process of a pump jack:

1. Wear of parts: Constant vibration can cause gradual wear of pump jack parts such as bearings (Figure 5), gears, gears and fasteners.

Vibratory loads can cause friction and shock between surfaces, eventually leading to surface wear and reduced performance. In the uppermost and lower positions of point D (Figure 3), that is, in the upper and lower "dead" points, the plunger, as it were, instantly stops, and then continues to move (see change in speed in Figure 4). In this case, since the plunger acceleration is extreme, the dynamic forces are also large. An increase in wear of the central support and at the junction of the cross member and the slider leads to an increase in gaps and, consequently, to the occurrence of shocks.

Figure 5. Damaged crank support due to vibrations
Rysunek 5. Podpora korby uszkodzona z powodu drgań

1. Damage and destruction: Intense vibration can cause damage and destruction of parts of the pump jack. With high amplitude and frequency of vibration, overloads, cracks and breakage can occur, especially in vulnerable areas of the structure. This can lead to serious problems such as loss of accuracy, reduced productivity, and even complete failure of the pump jack.
2. Degradation of accuracy: Vibration can adversely affect the accuracy of the pump jack. It can cause microscopic displacements and vibrations, which leads to deviations from the required parameters.

To reduce the effect of vibration on the aging of the pump jack, it is important to take appropriate measures. This may include the use of shock absorbing materials, the installation of vibration isolators, setting optimum operating conditions, regular vibration monitoring, and regular maintenance to detect and prevent damage and wear. It is also possible to use special vibration compensation and control technologies to minimize its impact on the pump jack.

Vibrations in oil pump jacks can be caused by various reasons. Some of them include:

1. Unbalance: If the pump jack components are not properly balanced, it may cause vibrations.

2. Incorrect installation: Improper installation of the pump jack or its components may result in uneven load distribution and therefore vibration. Incorrect installation of bearings, axles or other elements can also cause vibrations.
3. Parts worn or broken: Worn or damaged rocking parts can cause uneven movement and vibration. For example, worn bearings, gears, or drive belts can cause oscillation during operation.
4. Parameter mismatch: Mismatch of operating parameters such as speed, load or rotational speed may cause the pump jack to vibrate. For example, operating a pump jack at high speeds or extreme loads can cause unwanted vibrations.
5. Unbalanced working processes: Some working processes, such as uneven oil flow or imbalance in the rocking process, can cause vibrations in the pump jack. Improper system setup or maintenance can also be the cause of fluctuations.
6. Poor quality of materials or workmanship: The use of poor-quality materials or improper workmanship of pump jack components can lead to inconsistencies and deformations, which in turn cause vibrations.

It is important to note that vibrations in pump jacks can be caused by a combination of several factors. To prevent vibrations and their negative effects, it is necessary to carry out regular maintenance, control operating parameters, install components correctly and use high quality materials.

Loads: Loads on oilfield equipment can be caused by overloads, improper load distribution, overruns, or sudden changes in the production process. This can lead to wear and deformation of parts, cracks, breakage and reduced equipment performance (Figures 6–10).

Loads on the pump jack can have a significant impact on its aging and performance:

Figure 6. Conditions of connecting rods and traverses
Rysunek 6. Stan żerdzi łączących i poprzeczek

Figure 7. Deformation and fracture of connecting rods
Rysunek 7. Odkształcenie i spękanie żerdzi łączących

Figure 8. Fracture of connecting rod
Rysunek 8. Spękanie żerdzi łączącej

1. Wear of parts: increased loads on the pump jack can lead to wear of its key parts and components. Loads can cause friction, bending and deformation of parts, especially in places where they are subject to the greatest stress. Constant loads can cause wear on gears, bearings and other components of the pump jack, which can reduce its productivity and accuracy.

Figure 9. Deformation and wear of the connecting rod-traverse connection

Rysunek 9. Odkształcenie i zużycie złączenia żerdzi łączącej i poprzeczki

Figure 10. Connecting rod pin wear

Rysunek 10. Zużycie trzpienia żerdzi łączącej

Wear is a natural process that occurs as a result of friction, abrasion and corrosion. With the constant operation of oilfield equipment, parts and components can wear out, which leads to a decrease in their size, shape and functional characteristics. Wear can cause equipment performance degradation, increased friction, and systems to malfunction.

Wear is one of the main factors affecting the aging and performance of the pump jack. As the equipment is used, its parts and components gradually wear out. Here are some of the ways that wear can affect the aging process of a pump jack:

- Wear on parts such as bearings, bearings and gears can change their geometry and reduce the accuracy of the pump jack. Gradual wear can lead to gaps, misalignment and deviations from the specified parameters;
- Worn rocking parts become more vulnerable to damage and breakage. Excessive wear can cause friction, bending, wear, and failure of critical components. This can lead to reduced reliability, malfunctions, and even complete inoperability of the pump jack;
- Worn parts can reduce the performance and efficiency of the pump jack. Increased clearances and loss of accuracy can lead to incorrect movements, additional loads and loss of work efficiency. This can affect the processing speed, product quality and power consumption of the machine.

To reduce the effect of wear on pump jack aging, it is important to carry out regular maintenance, replace worn parts in time, and monitor their condition. In addition, the use of high-quality materials and components, the use of lubricants and proper setup and operation of the pump jack also help to increase its service life and reduce the negative effects of wear.

1. Damage and deformation: Excessive loads can cause damage and deformation of the pump jack. If the limit loads are exceeded, cracks, breakage and deformations can occur in the structure of the machine. This can lead to serious problems such as loss of accuracy, loss of geometry, loss of stability and damage to key components.
2. Decreased reliability and strength: Constant or frequent loads can reduce the reliability and strength of the pump jack. Increased stresses and strains can accelerate the fatigue process of materials and lead to deterioration of their mechanical properties. This may affect the performance and safety of the pump jack, as well as increase the risk of accidents.

It is important to take appropriate measures to reduce the influence of loads on pump jack aging. This may include optimizing work processes to reduce stress, using stronger materials and components, and properly setting up and maintaining equipment. It is also necessary to take into account the maximum loads and recommendations of the manufacturer when designing and operating the pump jack.

Corrosion: Corrosion is the process of destruction of materials through chemical reaction with the environment, especially in conditions of high humidity, the presence of harsh chemicals or sea water. Corrosion can cause rust, deposits, and progressive degradation of metal surfaces, resulting in poor performance and shortened equipment life.

Corrosion is a serious factor that can have a negative effect on pump jack aging and performance. Corrosion occurs as a result of a chemical reaction between the metal components of the machine and the environment, such as moisture, oxygen, or harsh chemicals. Here are some of the ways in which corrosion can affect the aging of a pump jack:

1. Damage to surfaces: Corrosion can cause damage to the surfaces of the metal parts of the pump jack. It can cause spots, cracks, chips and rust to form on surfaces, which can ultimately affect their strength and performance. Damaged surfaces can impair the contact properties and movement accuracy of machine parts.
2. Reduced reliability: Corrosion can reduce the reliability of the pump jack. Advanced corrosion can break or destroy key components such as bearings and gears. This can cause machine malfunctions and lead to emergency situations (Figure 11).
3. Degradation in performance: Corrosion can cause difficulty in movement and reduce the efficiency of the pump jack. Accumulation of corrosive deposits on surfaces can lead to jamming, seizing and increased friction between parts. This may affect the accuracy and performance of the machine.

Figure 11. Bottom support of the connecting rod
Rysunek 11. Podpora dolna żerdzi łączącej

To prevent the negative impact of corrosion on the aging of the pump jack, appropriate measures need to be taken to protect and manage the condition of surfaces and metal components. This may include the application of protective and anti-corrosion coatings, regular maintenance and cleaning of deposits, and environmental monitoring to minimize exposure to moisture, harsh chemicals, and other corrosive factors.

To minimize the negative impact of mechanical factors, regular checks, maintenance and replacement of worn parts are necessary. The use of modern technologies, materials and methods of control helps to improve the resistance of equipment to mechanical stress and extend its service life.

Conclusion

In summation, a thorough analysis of oil pump jack technical status and aging progression underscores their indispensable role in ensuring the reliability and efficiency of oilfield operations within the oil and gas industry. This research highlights the critical importance of employing a judicious analytical approach, enabling the early detection of potential anomalies and the implementation of preemptive measures. Such measures are not only pivotal for accident prevention but also for minimizing the requirement for extensive refurbishments, thus reinforcing the dual imperatives of safety and economic optimization that are inherent to oilfield activities.

The insights presented in this study shed light on the intricate mechanical factors that significantly influence oil pump jack performance and aging. They emphasize the necessity for ongoing vigilance through continuous monitoring and diligent maintenance practices to ensure the sustained operational efficiency of these crucial assets. This research contributes to a deeper understanding of the multifaceted dynamics underlying the oil and gas sector, providing actionable insights that are essential for oilfield operators, engineers, and industry stakeholders.

In a global context where energy resources remain the linchpin of economic and industrial development, the dependable performance of oil pump jacks is of paramount importance. By carefully considering the lessons learned from this research, stakeholders in the oil and gas industry can work towards meeting the increasing demands for energy while upholding the stringent standards of safety and sustainability, vital for both the environment and the industry's economic viability.

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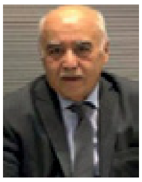

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