UDC 621.928.9:691.175.6 **DOI 10.33042/2311-7257.2025.112.1.38**

R. Salnikov, R. Rudyk

National University «Yuri Kondratyuk Poltava Polytechnic», Ukraine

ANALYSIS OF WEAR NATURE IN THE SCREW ASSEMBLY OF SO-150 TYPE PLASTERING UNITS

The screw mechanism is a key element of plastering equipment that ensures mortars transportation. During operation, its working surfaces are subject to intensive wear, which affects the productivity, supply uniformity and energy consumption of equipment. The paper investigates the mechanisms of material degradation, in particular the influence of abrasive and hydrodynamic wear. The wear intensity has been found to depend on the physical and mechanical properties of building mixtures, part geometry, and operating conditions. An analysis of the materials used to manufacture screw mechanism elements was performed, and measures were proposed to increase their durability. It has been established that the use of wear-resistant materials and optimization of geometric parameters allows to reduce the intensity of wear, extend the service life of the unit and reduce maintenance costs.

Keywords: *plastering unit, wear, material property, screw, stator, operating conditions*

Introduction

The screw assembly of the plastering unit SO-150 (Fig. 1) operates in difficult operating conditions, which leads to its rapid wear. One of the main problems is abrasive wear of the screw working surfaces and stator due to contact with building mixtures containing solid fractions. This alters the screw pair's geometry, impacting the tightness and efficiency of mix delivery. In addition, exposure to dynamic loads and variable operating modes contributes to the development of fatigue wear, which can lead to cracking and premature failure of parts.

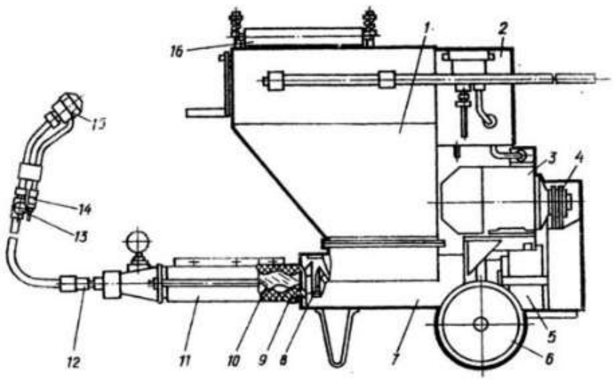

Fig. 1. Plastering unit SO-150:
1 – bunker; 2 – electric cabin; 3 – electric motor;
4 – V-belt drive; 5 – reducer;
6 – wheel; 7 – Screw body; 8 – supply screw;
9 – cartridge clip;
10 – pumping screw; 11 – clip body; 12 – hose;
13,14 – taps; 15 – rod; 16 – separator

The absence of an integrated approach to wear analysis and insufficient focus on operational factors complicate the selection of optimal materials and methods to extend the screw assembly's lifespan.

Thus, the urgent task is to study the nature of wear of the SO-150 screw assembly, identify the main degradation mechanisms and develop recommendations for reducing the intensity of wear and extending the service life of the unit.

Screw assembly wear occurs due to mechanical impact, abrasive building mixtures, and the corrosive environment present during equipment operation. As a result, there is a decrease in the efficiency of the unit, which is manifested in a decrease in the supply of mortar, uneven transportation and increased load on the drive mechanism.

In addition, changes in the geometry of the working elements lead to an increase in the power consumption of the unit and the need for frequent repairs or parts replacement. This significantly increases operating costs and affects the economic efficiency of the use of plastering units in the construction industry.

Analyzing the wear mechanisms in screw assemblies, it should be noted that their degradation is influenced by several factors, including screw speed, mortar transportation pressure, the chemical composition of building mixtures, as well as humidity level and ambient temperature.

A high concentration of abrasive particles in the solution causes gradual abrasion to the screw and stator material, leading to increased gaps between these elements, reduced sealing efficiency, and a loss in unit performance. Additionally, significant cyclic loads contribute to the development of fatigue phenomena in materials, potentially causing microcracks and subsequent destruction of structural elements.

One possible approach to reducing wear intensity is to use materials with increased wear resistance, such as polymer coatings or special wear-resistant steels. An important area of research is also the optimization of geometric parameters of the screw pair, which will improve the uniformity of the load and reduce local stress concentrations.

Additionally, it is worth considering methods for modifying building mixtures by introducing special additives that reduce the abrasive effect of solid particles on the working surfaces of the unit. Thus, studying the wear nature of the screw unit SO-150 and developing measures to increase its durability is an important scientific and technical task, significantly impacting the efficiency of plastering units and the overall productivity of construction work.

Analysis of Recent Research

The study of wear processes in the screw assembly of SO-150-type plastering units is important for assessing their reliability and efficiency in construction machinery. Since these units play a key role in ensuring equipment productivity, studying the factors causing wear allows for the development of design improvements and extends the service life of the mechanisms.

The wear of screw assemblies in plastering units is caused by several factors, including friction between parts, material fatigue, and the influence of aggressive environments, particularly abrasive particles in building mixture compositions.

Thus, according to studies [1], the main cause of rapid wear is precisely the abrasive effect caused by the presence of sand and stone particles in the mixture. The authors point out the need to improve the materials from which screw assemblies are made to increase their wear resistance, and also suggest the use of special coatings to reduce friction and increase the service life of mechanisms. He also notes that with the help of modern materials, such as high-strength alloys and composite coatings, it is possible to significantly increase the resource of the units, but this requires serious economic costs.

Another study described that the materials from which screw assemblies are made often do not withstand long-term loads due to the high speed of processing mortars and the use of low-quality components in construction. Scientists focus on the need to select materials taking into account specific operating conditions, since each element of the mechanism is subjected to a different level of load depending on the characteristics of the building mixture. The use of hard alloys and steels resistant to abrasive wear is proposed, which can significantly slow down the process of degradation of units. It is also recommended to use special lubrication systems to reduce friction between moving parts, which has a positive effect on their wear resistance [2].

Another study noted that the key factor affecting the wear of screw assemblies is not only materials, but also the design features of the units themselves. The author analyzes different screw pump designs and their effect on wear, proving that the correct distribution of load between individual mechanism elements can significantly reduce wear levels. His findings are confirmed by the results of experiments, which show that screw assemblies with optimized geometry and additional design changes show significantly less wear compared to traditional designs [3].

Under the conditions of using improved materials and designs, the problem of wear of screw assemblies in units remains relevant, since all possible operating conditions in which the unit may be are not taken into account. The author points out that the service life of the components is influenced by many external factors, such as temperature, humidity and aggressiveness of the working environment, which change during operation [4]. From his point of view, the optimal solution for reducing wear is implementing integrated systems to monitor mechanism condition, allowing real-time assessment of wear levels and forecasting maintenance needs.

Predicting wear and determining the residual life of screw assemblies is a complex problem that uses various mathematical models to solve. Studies [5-8] show that modern models, considering fatigue and friction factors, can accurately predict the wear nature of mechanisms, but they have limitations in conditions where unit operating factors differ from standard ones. The researcher also proposes to improve the models by taking into account the specific parameters of the construction machines, which allows for more accurate prediction of wear in real conditions.

Despite these achievements, there is still a need for more detailed studies that will allow determining more accurate parameters for predicting wear in SO-150 units. For example, research [8-12] found that optimizing screw pump operation through computer simulations can significantly reduce component wear. The authors recommend integrating these technologies into the unit management system to identify potential problems in a timely manner and make decisions about repairing or replacing parts before they fail.

Thus, existing studies show that screw assembly wear in units depends on several factors, such as material choice, design features of mechanisms, operating conditions, and monitoring methods. However, to date, no single solution has been found to completely eliminate the wear problem.

This is also confirmed by the works of other authors, who emphasize the importance of an integrated approach to improving structures and materials. More research is needed to more accurately determine methods for minimizing wear in real operating conditions and increasing the efficiency of using such units in construction [12-15].

Thus, the problem of screw assembly wear in SO-150-type units remains an important topic for scientific research, with existing works providing valuable recommendations to improve the reliability and efficiency of these mechanisms.

Research Goal

The purpose of this study is to analyze the wear nature of the screw assembly in SO-150-type plastering units, determine factors affecting its wear resistance, and develop recommendations to increase the efficiency and durability of these mechanisms. Given the importance of screw assemblies in pumping construction mixtures, the study aims to identify wear causes and develop methods to minimize it, improving the operational characteristics of the units.

To achieve this goal, the following tasks must be completed:

- analyze existing designs of screw assemblies and determine the main causes of their wear in SO-150 type units;
- to assess the influence of abrasive properties in building mixtures on the wear of screw assembly working surfaces;
- to investigate the materials from which screw assemblies are made and their wear resistance under operating conditions;
- develop recommendations for selecting materials and structures that help reduce component wear levels;
- determine the effectiveness of implementing screw assembly condition monitoring systems for timely wear detection and prevention.

Methodology and Results

Wear in the screw assembly of a plastering unit is a multifactorial process dependent on several factors, particularly design features, manufacturing materials, operating conditions, and the characteristics of the building mixtures being pumped.

One main factor affecting screw assembly wear is friction between the working surfaces of the screw and the housing. During unit operation, significant friction occurs, accelerating material wear, especially when working with abrasive mixtures like plaster mortars containing sand and other solid particles.

This leads to a gradual decrease in the efficiency of the unit and an increase in maintenance costs.

The accuracy of manufacture and the correct installation of screw assemblies directly affect their efficiency and durability.

The abrasive properties of building mixtures used in plastering units are also a main factor in screw assembly wear. Plastering solutions containing sand and other solid particles increase wear on the working surfaces of the screw and unit body. Abrasive particles cause micro-impacts and scratches on the surfaces, leading over time to decreased pumping efficiency and the need for repair or replacement of worn parts.

The operating temperature of the plastering unit also plays an important role in screw assembly wear. Increased temperature from prolonged unit operation can soften materials and reduce their strength, accelerating wear. However, excessively low temperatures can also negatively affect materials, causing cracks and deformation. Optimal operating temperature conditions are crucial for reducing the wear rate of the screw assembly.

When considering the materials used to make the screw assembly, an important factor is the wear resistance level of the unit parts. If materials with low wear resistance, such as standard steel without special coatings, are used, the wear process of the working parts can accelerate significantly. The use of materials with increased wear resistance, such as alloy steels or alloys with hard coatings, can greatly enhance the unit's durability.

The geometry of the working parts in the screw assembly is also an important factor affecting wear levels. Mismatch between the screw and housing can lead to uneven load distribution, increasing friction intensity and wear in specific areas (Fig. 2).

Fig.2. Uneven wear of rubber plaster clips for the SO-150 unit

The screw assembly of the plastering unit CO-150 experiences significant abrasive wear during operation. The image shows a cut-away casing, enabling a detailed analysis of damage nature and material degradation after prolonged use. Visible wear traces indicate uneven load distribution during unit operation, caused both by screw and casing geometry and the abrasive action of mortar particles. A change in wall thickness affects sealing efficiency and unit productivity. Microstructure analysis of the worn surface helps determine material degradation mechanisms and develop measures to reduce wear intensity.

The rubber sleeve in the screw assembly of the plastering unit must have high wear resistance, elasticity, and the ability to withstand mechanical loads, friction, and the impact of abrasive particles. Various materials can be used for its manufacture, depending on operational characteristic requirements.

One of the most common materials for making rubber clips is nitrile rubber (NBR). It has high wear resistance to most chemicals, making it the best choice for working in aggressive environments.

In addition, nitrile rubber has good elasticity and the ability to compensate for deformations during operation, which reduces the load on the screw assembly structure.

To increase the wear resistance of the cage, thermoplastic elastomers (TPR) can also be used, combining the properties of thermoplastic materials and rubber products. They offer high wear resistance and the ability to restore shape after deformation. Thermoplastic elastomers are less sensitive to temperature fluctuations and provide improved mechanical strength compared to traditional rubber materials.

Another option is polychloroprene (CR). This material withstands friction well and has high elasticity, which allows it to adapt well to working conditions in aggressive environments, such as building mixtures with abrasive particles.

In some cases, synthetic rubbers based on ethylene propylene (EPDM) or styrene-butadiene rubber (SBR) can be used, which are characterized by excellent resistance to water and various chemicals. They also have good mechanical properties and resistance to high temperatures.

Recently, composites have been used for the manufacture of rubber clips, which combine rubber materials with reinforcing fibers (for example, with carbon fibers), which can significantly increase their wear resistance and strength. These materials are used to create clips that can withstand intense mechanical stress and abrasive particles.

Thus, a variety of materials can be used for manufacturing rubber sleeves in the screw assembly of the plastering unit, including nitrile rubber, butyl rubber, thermoplastic elastomers, polychloroprene, and synthetic rubbers. This variety allows for optimizing performance characteristics according to specific operating conditions. The choice of material depends on the requirements for wear resistance, elasticity, and resistance to abrasive particles and chemicals.

The screws of plastering units must also have high wear resistance, strength and the ability to withstand heavy mechanical loads, friction, as well as the effects of aggressive building mixtures (Fig. 3). To ensure these properties, it is important to choose materials that meet specific operating conditions.

Fig.3. Gwent plastering unit SO-150
after a long work cycle

One main material for manufacturing screws is high-quality alloy steel, particularly 40X or 35XGS steels. These steels offer good wear resistance and strength, allowing them to withstand mechanical loads, friction, and the impact of abrasive particles often found in building mixtures. Alloying elements, such as chromium, manganese, and molybdenum, enhance their wear and corrosion resistance.

For work in conditions of high humidity or aggressive environments, stainless steels can be used, such as steel grade 12X18H10T.

These materials are resistant to corrosion, making them ideal for working in conditions of high humidity and aggressive environments. They also have good mechanical strength and abrasion resistance, but require additional processing to ensure high wear resistance.

To ensure maximum wear resistance, screws can also be made from high-alloy steels containing tungsten or chromium. These elements significantly increase material hardness and wear resistance, which is crucial for screws working with abrasive mixtures. Such steels withstand aggressive environments and challenging operating conditions well, but their cost is higher than standard alloy steels.

In some cases, special cast iron can be used, which has increased wear resistance due to the addition of carbon and silicon. Cast iron is less flexible, but has high hardness and resistance to abrasive wear. However, it requires careful monitoring of operating conditions, as it can be brittle under high loads.

The use of titanium alloys, which have high strength, corrosion resistance and wear resistance. restricts use in industrial units.

Thus, various materials are used for manufacturing screws in plastering units, including alloy steels, stainless steels, high-alloy steels, and cast iron. The choice of material depends on the unit's operating conditions, mechanical load levels, the influence of abrasive particles in building mixtures, as well as corrosion resistance requirements and material cost.

Assessing the wear of screw assemblies in plastering units is an important task for increasing their durability and efficiency. Various experimental and theoretical methods are used for this purpose, each with its own advantages and features. Experimental methods include visual analysis, microscopic examination, measurement of geometric parameters, physical and mechanical tests, as well as laboratory and field testing. Visual analysis helps assess the degree of part wear without complex equipment, detecting cracks, dents, burrs, and color changes, which may indicate overheating or material structure changes. For a more detailed study, microscopic analysis is used to examine microstructural changes, microcrack formation, and wear mechanisms. Measuring geometric parameters involves using contourographs, profilometers, and laser scanners to accurately determine changes in the screw and stator dimensions, revealing degradation patterns in the working surface.

Fig.4. Research on the surface hardness of the screw using a Rockwell hardness tester

Physical and mechanical tests involve assessing hardness (Fig. 4), microhardness, impact strength, and wear resistance of materials used in screw assemblies. Laboratory tests are conducted in specialized bench installations, where conditions close to real ones are created, allowing for the assessment of various factors' influence on wear intensity. Field tests involve operating the unit in real construction conditions, followed by result analysis, providing the most objective information about part durability. Theoretical methods for assessing wear rely on numerical modeling, mathematical analysis, and empirical dependencies. Numerical modeling, using computer programs like the finite element method, predicts screw assembly behavior under load, identifies critical zones, and evaluates wear mechanisms. Mathematical analysis involves using equations for friction, wear, and mechanical stress to quantitatively assess material loss and predict part lifespan. Empirical relationships are based on generalizing experimental data, enabling the development of analytical models that account for various parameters' influence on the wear process. The combination of experimental and theoretical methods provides the most reliable wear assessment, contributing to the development of effective measures to enhance reliability, optimize design, and select materials with improved performance characteristics.

An important method for assessing screw material condition is determining its hardness (for example, on the Rockwell scale). Hardness testing helps evaluate the material's physical and mechanical properties after long-term operation, detecting changes that may indicate material fatigue or degradation due to mechanical loads and abrasive environments. Hardness dynamics can reveal wear processes caused by constant contact between the screw and building mixtures containing solid particles. High material hardness may indicate increased wear resistance but can also lead to brittleness and a higher risk of microcracks. Analyzing test results allows the assessment of material effectiveness and the development of recommendations for selecting optimal structural solutions to enhance screw assembly durability.

For analyzing the hardness of screw unit components in the SO-150 plastering machine, the Rockwell method is particularly useful as it allows assessing material property changes after prolonged operation. During screw and stator operation, surface wear occurs gradually due to constant contact with building mixtures containing solid particles. Rockwell hardness testing helps identify areas with the most severe degradation and evaluate the degree of mechanical fatigue.

A key advantage of the Rockwell method is the ability to perform tests directly on assembled parts in use without cutting separate samples. This enables rapid data collection on the screw unit's surface condition and timely determination of the need for replacement or repair. Additionally, using various hardness scales (HRC, HRB, HRA, etc.) allows measuring the hardness of both hardened steels and softer materials used in the unit's construction.

The Brinell method determines material hardness by pressing a steel or tungsten carbide ball of a specific diameter into the surface under a fixed load. Once the load is removed, the diameter of the indentation is measured to calculate hardness. This method is particularly effective for analyzing soft and medium-hard materials used in construction machinery and mechanical systems, including screw unit components.

Applying the Brinell method in screw unit diagnostics helps determine mechanical properties after operation and assess wear levels. For example, after extended use, hardness values can be compared to the material's initial characteristics, providing insights into structural changes and physical-mechanical properties. This is essential for predicting component lifespan and selecting optimal materials for manufacturing. The measurements carried out also make it possible to predict the residual life of parts and make timely decisions on their replacement or repair, which is important to ensure the stable operation of the unit. In addition, the obtained data can be used to improve the methods of thermal and chemical-thermal treatment of the screw material, which will contribute to the improvement of its operational characteristics. The use of modern hardness measurement methods provides high accuracy of analysis and allows you to detect even minor changes in the structure of the material that occur during operation. Thus, hardness research is an important step in a comprehensive analysis of screw assembly wear, which makes it possible to assess the efficiency of materials, determine degradation patterns, and develop recommendations for improving the durability of plastering units.

Archard's law is one of the most common empirical approaches to estimating the intensity of wear of materials in tribological systems, in particular in friction units of machines and mechanisms. It is based on the assumption that the volume of wear material is proportional to the applied load, the length of friction, and inversely proportional to the hardness of the material. The basic equation of Archard's law is of the form:

$$V = \frac{KWL}{H}, \qquad (1)$$

where V – volume of worn material, *m³*;

K – wear coefficient, which depends on the pair of materials in contact and load mode;

W – normal load force acting on contacting surfaces;

L – slip path, i.e. the distance to which the contact point moves during operation;

H – hardness of the contact surface material.

Archard's law is widely used to analyze the wear of parts in industrial settings, in particular to evaluate the durability of the screw assembly of plastering units. In the case of this unit, which operates under conditions of high abrasive load due to contact with mortar, the amount of wear is largely determined by the parameters of the screw and cage materials, their microstructure and hardness. At the same time, during the operation of the plastering unit, the main factors affecting wear are not only the mechanical impact of the contact surfaces, but also the presence of abrasive particles in the solution, which accelerates material degradation.

To take into account the influence of such factors, Archard's law can be modified by introducing additional coefficients that correct the equations depending on the operating modes and physicochemical properties of the medium.

One approach is to use experimental dependencies that allow the determination of the wear coefficient K for specific materials and operating conditions. The value of this coefficient can vary widely and depends on factors such as surface roughness, process temperature, chemical composition of the medium in contact with parts.

The wear of the unit's screw assembly can also be estimated based on the intensity of mass or volume loss from the working surfaces over a certain period of operation. In this case, the volumetric wear rate can be determined by the formula:

$$\dot{V} = \frac{KW\upsilon}{H}, \qquad (2)$$

where $\dot{V}$ – material loss rate per unit of time, *m/s*;

υ – relative sliding speed between propeller and clip, *m/s*.

This equation allows you to estimate not only the total volume of wear, but also its rate, which makes it possible to predict the service life of the screw assembly and optimize its design to reduce the negative impact of operational loads.

In practice, experimental stands that simulate the operating conditions of a screw assembly can be used to quantify wear parameters according to Archard's law. In such studies, the decrease in the mass of parts or their geometric changes after a certain time of operation is measured. By comparing the results obtained with theoretical calculations, it is possible to clarify the wear coefficient and identify the most critical factors affecting the durability of parts. An important aspect is also monitoring the condition of the contacting surfaces, as uneven wear can lead to a violation of the tightness of the screw pair and a decrease in the efficiency of mortar supply.

The hydrodynamic wear model describes the process of material loss due to the action of a fluid flow containing solid particles, or due to the influence of alternating pressure and fluid flow velocity. This is relevant for analyzing the wear of parts operating in liquid media, particularly for the SO-150 plastering unit's screw assembly, where the working body remains in constant contact with the mortar. The main factors affecting hydrodynamic wear are flow velocity, medium viscosity, the presence of abrasive particles, and the geometry of surfaces interacting with the flow.

In the case of a plastering unit's screw assembly, the mortar flow passes through the working gap between the screw and the stator, generating alternating loads on the part surfaces. The main mechanism of hydrodynamic wear in such a system is associated with the abrasive action of suspended particles that move with the flow and interact with the surface material. The amount of this wear is determined by the flow rate and the concentration of abrasive inclusions.

To quantify hydrodynamic wear, an empirical dependence is used, which expresses the loss of material due to the action of flow:

$$\dot{V} = k\left(\frac{\tau_w}{H}\right)^m, \quad (3)$$

where k – empirical coefficient depending on the physical and mechanical properties of the material;

τ_w – tangential flow stress on the surface of the part, *Pa*;

m – exponent, taking into account the nature of flow interaction the with the surface.

The tangential flux stress can be determined by the classical equation:

$$\tau_w = \mu \left.\frac{\partial v}{\partial y}\right|_{y=0}, \quad (4)$$

where v – fluid velocity in the direction of flow, *m/s*;

y – coordinate, perpendicular to the surface.

A high value τ_w contributes to an increase in the intensity of wear, which is typical for nodes operating in turbulent flows.

Additionally, when suspended particles cause erosive effects, the wear rate can be estimated based on the dependence:

$$\dot{V} = C d_p^n v_p^p, \quad (5)$$

where C – empirical coefficient;

d_p – average particle size, *mm*;

v_p – particle velocity relative to the surface, *m/s*;

n and p – exponents depending on the type of flow and the physical and mechanical properties of the material.

For the practical application of hydrodynamic wear models, experimental studies are required to determine the coefficients in the equations and account for flow characteristics, including regime (laminar or turbulent), hydrodynamic pressure, and variable loads. Optimizing the screw assembly design, selecting materials with high erosion resistance, and applying friction-reducing coatings can significantly decrease the intensity of hydrodynamic wear and extend the unit's service life.

By analyzing the aforementioned wear models, it becomes possible to predict the lifespan of screw pair components. This is a key factor in ensuring the durability and reliability of the screw assembly in plastering units. Estimating the residual lifespan helps determine maintenance intervals, prevent unexpected failures, and optimize equipment operating costs.

The primary approach to resource prediction involves determining the wear rate of components and calculating the time required to reach critical wear, beyond which further operation of the unit becomes impractical or hazardous. Kinetic models are also utilized, describing the dependence of wear rate on operational time. The wear rate can be expressed in the differential form:

$$\frac{dh}{dt} = -k \cdot f\left(p, v, T\right), \quad (6)$$

where h – thickness of the wear layer, *mm*;

t – operating time, *s*;

k – empirical coefficient;

$f\left(p, v, T\right)$ – function that depends on pressure, relative velocity and temperature.

By integrating this equation, it becomes possible to predict changes in the part's thickness over time and determine the moment when wear reaches its critical limit.

Hydrodynamic wear, typical for components operating in liquid media, is evaluated based on the tangential stress of the flow and its interaction with abrasive particles. In this case, resource prediction relies on the following equation:

$$h(t) = h_0 - \int_0^t \dot{V} dt, \quad (7)$$

where h_0 – initial thickness of the part, *mm*.

To account for variable loads, damage mechanics methods are employed, enabling the assessment of microdefect accumulation in the material under cyclic loading. Specifically, an approach based on the principle of linear damage accumulation is utilized:

$$D = \sum_{i=1}^{n} \frac{N_i}{N_{fi}}, \quad (8)$$

where D – accumulated damage, *mm*;

N_i – number of load cycles at a certain stress level;

N_{fi} – the maximum number of cycles to failure at this level.

If $D \geq 1$, the part will be considered to have reached the final state.

For practical prediction, numerical methods are used, in particular the finite element method, which allows modeling wear processes at the material microstructure level and analyzing the stress-strain state in the assembly's real operating conditions.

Thus, predicting the service life of the screw assembly parts in the plastering unit SO-150 is a complex task that requires a comprehensive approach, considering various wear mechanisms and using mathematical models to calculate the remaining service life. Improving forecasting methods enables timely replacement of parts, reducing repair costs and ensuring uninterrupted operation of construction equipment.

Conclusions

The results of the conducted research confirmed that wear in the screw assembly of the plastering unit is a complex and multifactorial process, depending on various operational, mechanical, and materials science factors. The analysis found that the main mechanisms for material degradation are abrasive wear, hydrodynamic wear, and fatigue processes caused by variable loads. Abrasive wear is dominant, as construction mixtures contain solid particles that, during transportation by the screw assembly, cause gradual material loss on the contact surfaces. In addition, hydrodynamic wear results from the high-speed flow of the solution, which creates tangential stresses on the stator and screw walls, further accelerating part degradation due to erosion processes.

The application of mathematical methods for assessing wear enabled us to establish quantitative characteristics for material loss and identify the main parameters affecting the durability of the screw assembly. Using the Archard equation, material losses can be estimated based on load, material hardness, and contact length of the working surfaces. The analysis showed that increasing material hardness can significantly reduce the wear rate, but it also requires considering the tribological properties of contact pairs to prevent excessive friction and local mechanical damage. Additionally, the use of hydrodynamic models enabled us to assess the impact of hydrodynamic loading on changes in the surface layer of parts. The results indicate that optimizing flow rate and controlling the viscous properties of the mortar can help reduce hydrodynamic wear, potentially increasing the service life of the screw assembly.

Special attention was given to methods for predicting the service life of parts. The proposed approach, based on the differential equation for the change in wear layer thickness, will provide a mathematical model for the dependence of the unit's residual service life on operating time and working environment parameters. The use of modern materials with increased wear resistance, such as polymer coatings or modified composite materials, can significantly extend the unit's service life.

The practical significance of the results lies in the potential to develop new design solutions for increasing the durability of screw assemblies in plastering units. In particular, optimizing the geometric parameters of the screw and stator, as well as using advanced surface treatment methods, can significantly affect wear levels and improve the operational characteristics of the assemblies. An important direction for further research is the development of adaptive systems to monitor the condition of the screw assembly, enabling real-time assessment of wear and predicting the need for part replacement.

Thus, the conducted research provided important theoretical and practical results that can be used to improve screw assembly designs, enhance work efficiency, and optimize the technological parameters for plastering unit operation. The wear patterns and mathematical models can be applied in mechanical engineering to create more durable and reliable mechanisms, contributing to reduced operating costs and increased productivity in construction processes.

References

1. Baladinskyi, V.L., Livinskyi, O.M., Khmara, L.A., et al. (2001). Construction Machinery: Textbook. Kyiv: Lybid.

2. Baladinskyi, V.L., Nazarenko, I.I., & Onyshchenko, O.H. (2002). Construction Machinery: Textbook. Kyiv – Poltava: KNUCA – PoltNTU.

3. Onyshchenko, O.H., Drachenko, B.F., & Holovkin, O.V. (1998). Mechanization of Finishing Works in Construction. Kyiv: Urozhai.

4. Holovkin, O.V., Nadobko, V.B., & Ust'yantsev, V.U. (1996). Universal Mortar Mixing Unit. In Progressive Technologies and Machines for the Production of Building Materials, Products, and Structures: All-Ukrainian Conference: Abstracts (pp. 98–100). Poltava.

5. Kucherenko, L.V., Rabocha, T.V., & Strilets, Ya.O. (2013). Modern Approaches to Improving the Efficiency of Thin-Layer Plaster Coating Application. Scientific and Technical Collection "Modern Technologies, Materials, and Structures in Construction", 1(14), 47–50.

6. Korobko, B.O., Virchenko, V.V., & Shapoval, M.V. (2018). Feed Solution in the Pipeline with the Compensators Mortar Pump of Various Design Solutions Pressure Pulsations Degree Determination. International Journal of Engineering & Technology, 7(3.2), 195–202.

7. Ruhrberg, K., Woishnis, W., & Baur, E. (Eds.). (2016). Chemical Resistance of Engineering Thermoplastics. Elsevier Inc., William Andrew.

8. Averko-Antonovich, L.A., Averko-Antonovich, Y.O., Davletbaeva, I.M., & Kirpichikov, P.A. (2008). Chemistry and Technology of Synthetic Rubber. M.: Chemistry.
9. Yan, D., Tang, Q., Kovacevic, A., et al. (2018). Rotor Profile Design and Numerical Analysis of 2-3 Type Multiphase Twin-Screw Pumps. Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, 232(2), 186–202.
10. Li, Z., Zhang, R., Gao, Y., et al. (2008). Profile Analysis and Simulation of Twin-Screw Pump. China Petroleum Machinery, 36(3), 41–44. (In Chinese)
11. Ohbayashi, T., Sawada, T., & Hamaguchi, M. (2001). Study on the Performance Prediction of Screw Vacuum Pump. Applied Surface Science, 169, 768–771.
12. Hu, B., Cao, F., & Yang, X. (2016). Theoretical and Experimental Study on Conveying Behavior of a Twin-Screw Multiphase Pump. Proceedings of the Institution of Mechanical Engineers, 230(4), 304–315.
13. Pfaller, D., Brümmer, A., & Kauder, K. (2011). Optimized rotor pitch distributions for screw spindle vacuum pumps. Vacuum, 85(12), 1152–1155.
https://doi.org/10.1016/j.vacuum.2011.03.002
14. Ohbayashi, T., Sawada, T., Hamaguchi, M., et al. (2001). Study on the performance prediction of screw vacuum pump. Applied Surface Science, 169–170, 768–771.
https://doi.org/10.1016/S0169-4332(00)00788-1
15. Wang, J., Cui, F., Wei, S., et al. (2017). Study on a novel screw rotor with variable cross-section profiles for twin-screw vacuum pumps. Vacuum, 145, 299–307.
doi: https://doi.org/10.1016/j.vacuum.2017.09.006

Author: Roman SALNIKOV,
Postgraduate student,
Department of Industrial Engineering and Mechatronics National University «Yuri Kondratyuk Poltava Polytechnic»
САЛЬНІКОВ Роман Юрійович,
Здобувач вищої освіти третього рівня, кафедри галузевого машинобудування та мехатроніки,
Національний університет «Полтавська політехніка імені Юрія Кондратюка»
E-mail: salnikov.ry@nupp.edu.ua
ID ORCID: https://orcid.org/0009-0001-0408-4358

Author: Rostyslav RUDYK,
Postgraduate student,
Department of Industrial Engineering and Mechatronics National University «Yuri Kondratyuk Poltava Polytechnic»
РУДИК Ростислав Юрійович,
Здобувач вищої освіти третього рівня, кафедри галузевого машинобудування та мехатроніки,
Національний університет «Полтавська політехніка імені Юрія Кондратюка»
E-mail: rostyslavrudyk@nupp.edu.ua
ID ORCID: https://orcid.org/0000-0001-8386-977X

АНАЛІЗ ХАРАКТЕРУ ЗНОШУВАННЯ ГВИНТОВОГО ВУЗЛА ШТУКАТУРНИХ АГРЕГАТІВ ТИПУ СО-150

Р.Ю. Сальніков, Р.Ю. Рудик
Національний університет «Полтавська політехніка імені Юрія Кондратюка», Україна

Дослідження присвячено аналізу характеру зношування гвинтового вузла штукатурних агрегатів типу СО-150, який є ключовим елементом, що забезпечує транспортування будівельних розчинів. Основна увага приділена механізмам деградації матеріалів, зокрема абразивному та гідродинамічному зношуванню, які виникають внаслідок контакту робочих поверхонь із твердими частками будівельних сумішей. Встановлено, що інтенсивність зношування залежить від фізико-механічних властивостей матеріалів, геометрії деталей та умов експлуатації агрегату. У статті проведено аналіз матеріалів, які використовуються для виготовлення гвинта та статора, зокрема легованих сталей, нітрильного каучуку, термопластичних еластомерів та композитів. Доведено, що застосування зносостійких матеріалів і оптимізація геометричних параметрів дозволяють зменшити інтенсивність зношування та продовжити термін служби вузла. Також розглянуто вплив таких факторів, як швидкість обертання гвинта, тиск транспортування розчину, температура та вологість навколишнього середовища. Результати досліджень показали, що основним механізмом зношування є абразивний вплив твердих часток у будівельних сумішах, який призводить до втрати матеріалу та зміни геометрії робочих поверхонь. Гідродинамічне зношування, викликане високошвидкісним потоком розчину, також сприяє деградації деталей. Запропоновано заходи для зниження зношування, такі як використання покриттів із підвищеною зносостійкістю, оптимізація конструкції гвинтової пари та впровадження систем моніторингу стану вузла. Практична значимість роботи полягає у можливості застосування отриманих результатів для підвищення довговічності штукатурних агрегатів, зменшення витрат на обслуговування та підвищення ефективності будівельних процесів. Подальші дослідження можуть бути спрямовані на розробку нових матеріалів із покращеними трибологічними властивостями та вдосконалення методів прогнозування зношування.

Ключові слова: *штукатурний агрегат, зношування, властивість матеріалу, гвинт, статор, умови експлуатації*