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ALGORITHMICITY OF DETERMINATION OF EFFICIENCY OF STORAGE OF GRAIN HARVESTERS

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Abstract. The article conducts research and generalization of storage efficiency of combine harvesters. The most efficient storage of machines is provided indoors by agro-industrial enterprises. However, about 60% of the combine harvester fleet is stored in open areas. Due to limited economic opportunities in many organizations there are cases of non-compliance with the rules of storage of machines and low quality of work on corrosion protection. Due to corrosion during storage of machines and equipment, their durability is reduced, the complexity of maintenance and repair operations is increased. The most susceptible to corrosion are gear teeth and bush-roller chains, threaded connections, working parts of tillage machines: plowshares, cultivator legs and others. Due to corrosion, the cost of maintaining the fleet increases. Costs for maintenance and repair of working tools of tillage implements in organizations range from 32 to 78% of the cost of machines. In recent years, there has been a tendency to reduce the cost of corrosion protection in the use of waste preservatives. However, there are no specific recommendations in the literature for the preparation of such preservatives and the results of their tests for combine harvesters.

Key words: durability, efficiency, storage, corrosion, nanopowder, mineral oils, resource-saving compositions.

Introduction

Based on the analysis of the results of monitoring the storage conditions [1] and corrosion damage of combine harvesters [2], it is necessary to monitor the storage conditions and corrosion damage of combine harvesters [3]. To analyze modern domestic and world trends in the creation of conservation warehouses to protect combine harvesters from corrosion during storage [4].

To date, no theoretical prerequisites have been developed for the selection of rational conservation compositions for corrosion protection of combine harvesters during storage in different natural and climatic conditions [5].

To do this, many researchers suggest using the corrosion rate of the machine surface after applying the composition [6].

Formulation of problem

The optimal conservation composition is the one that will provide the minimum cost to ensure the maximum possible protection of the machine from corrosion [7]. However, when choosing preservatives [8], keep in mind that when the machine is put into operation after storage, preservatives are removed [9]. Therefore, we proposed a technical and economic criterion for the effectiveness of conservation warehouses [10], according to which the optimal composition is considered to provide sufficient durability (rational protective capacity, taking into account the corrosive environment of the region where harvesters will be stored) at minimum cost [11].

$$C_{ks}/K_d \rightarrow min \quad (1)$$

where C_{ks} – specific cost of conservation composition, UAH/kg;

K_d – rational protective ability, which provides the necessary durability of the conservation composition.

Analysis of recent research results

For storage of combine harvesters are exposed to a large number of external and internal factors [12], but the rate of atmospheric corrosion is mainly determined by temperature and humidity [13]. The section summarizes mathematical models developed by various scientists to determine the protective ability of conservation compositions by the rate of atmospheric corrosion [14]. Their analysis allowed us to choose a regression equation that describes the corrosion rate of steel parts depending on the parameters of the environment [15]. It is obtained on the basis of statistical processing of long-term observations and corrosion tests:

$$V = 0.78 \cdot RH + 1.22 \cdot T + 0.173 \cdot \mathrm{Cl} + 0.3 \cdot \mathrm{S} - 52.68 \quad (2)$$

where RH – average annual relative humidity

T – average annual temperature, °C;

Cl – average annual concentration of chlorides, mg/m^3;

S – the average annual concentration of sulfur dioxide, mg/(m^3 per day).

Analysis of the state of air pollution by harmful emissions in the regions [16], taking into account the maximum allowable concentration in Ukraine (sulfur dioxide 0.05 mg/m^3, chlorides 0.1 mg/(m^3 per day) and our comparative calculations of atmospheric corrosion showed that the impact of harmful emissions absorbed in 0.3…0.5%. Therefore [17], to determine the rate of atmospheric corrosion of combine harvesters, you can use the equation of influence of meteorological factors only:

$$V = 0.78 \cdot RH + 1.22 \cdot T - 52.68 \quad (3)$$

Based on the obtained formula, it is proposed to compile maps of atmospheric corrosion of machines in different regions [18]. Based on the corrosion maps, different preservatives with different corrosion resistance can be recommended [19], depending on the corrosion rate in the region. It is proposed to take into account the corrosion aggressiveness of the region by the correction factor Corrosion aggressiveness of the region [20]. It is defined as the ratio of the corrosion rate in the i-region to the corrosion rate in the base region [21]. For the base region, data on the protective effectiveness of conservation formulations are obtained experimentally [22].

Thus, taking into account the proposed criterion, the rational composition in the i-region will be a composition that will satisfy the requirement:

$$C_{ksi}/(K_{db} \cdot K_{ap}) \rightarrow \text{min}, \quad (4)$$

where C_{ksi} – specific cost of the i-composition of the conservation composition, g kg;

K_{db} – rational protective capacity of the conservation composition for the base region;

K_{ap} – he coefficient of corrosion aggressiveness of the i-region, which is defined as the ratio of the corrosion rate in the region to the corrosion rate in the base region (determined taking into account the developed maps of corrosion regions).

The analysis of the obtained model shows that in order to increase the efficiency of corrosion protection of combine harvesters, low-cost warehouses are required [23], which provide the necessary durability. To reduce the cost of conservation compositions [24], it is advisable to use as their components waste vegetable oils [25] and waste mineral oils [26]. However, the proposed approaches require experimental and production testing.

Purpose of research

The purpose of research is to create resource-saving conservation warehouses for corrosion protection of combine harvesters during long-term storage.

Research results

The comparative tests of anticorrosive properties of compositions with addition of nanopowders are carried out in the article. A laboratory stirrer with an electric motor was used to make the preservative compositions. The viscosity of the compositions was determined according to DSTU 8420 "Methods for determining the conditional viscosity" to obtain corrosion inhibitors as a raw material used waste rapeseed oil, and as a solvent spent motor and transformer oils. Based on this technology, a new corrosion inhibitor and preservative composition have been developed. When performing research used samples of steel Article 3 coated with preservatives. The samples were rectangular plates measuring 50x50 mm and 3.0 mm thick. The samples were degreased with acetone and dried in the open air. To apply preservative compositions, the samples were immersed for 30… 40 s in the preservative material at room temperature. Then the samples were removed and kept in air in a suspended state for 24 hours. The diameter of the spreading drop of the preservative composition applied to the steel surface was taken as the wetting characteristic. The hydrophobicity of the preservative compositions was evaluated by the wetting angle of a drop of water on a coated metal surface using an installation whose main components are a catheter and a cuvette measuring cell, using software.

The adhesion strength of preservatives to the metal surface was measured on a PosiTest AT adhesiometer. The comparative resistance of preservative coatings to washing away was determined by irrigating them at the same intensity in the shower in a certain sequence. The criterion for resistance of coatings to washing was the difference in the weight of the samples before and after irrigation. BP-310S scales of the second class of accuracy were used for weighing of samples. For comparative corrosion tests of preservative compositions as a thermal-moisture chamber used air sterilizer HS62A. The duration of the tests was set before the appearance of traces of corrosion on the samples. Electrochemical studies using the IPC-ProMF potentiostat were performed to study the mechanism of corrosion inhibition by preservative compositions.

Field tests of conservation compositions were performed on samples in Cherkasy, Kyiv and Khmelnytsky regions. Plates with applied preservatives were hung in a vertical position on the rods with nylon thread. The distance between the plates was at least 150 mm. The tests were conducted outdoors, as well as under a canopy and indoors (metal garage). The total duration of the tests was 12 months. During the tests, the plates were inspected to determine the time of appearance of the first corrosion center.

Corrosion destruction was considered corrosion cells on the surface of metal plates in the form of individual points, spots, threads, ulcers. The ratio of the area of corrosion foci to the area of the tested plate in percent was used to assess the protective ability of preservative materials.

Of the studied compositions, the best wetting of the steel surface are compositions containing mineral oils. Increasing the content of corrosion inhibitor in the preservative composition increases the hydrophobicity of the surface of the coated sample (Fig. 1).

Corrosion inhibitor Telaz-L, obtained from rapeseed oil, has the best adhesive strength and resistance to washing. The effect of the content of corrosion inhibitor in the spent engine oil on the adhesive strength of the preservative composition is shown in Fig. 2.

The effect of the content of corrosion inhibitor in the spent engine oil on the corrosion resistance of the preservative composition is shown in Fig. 3.

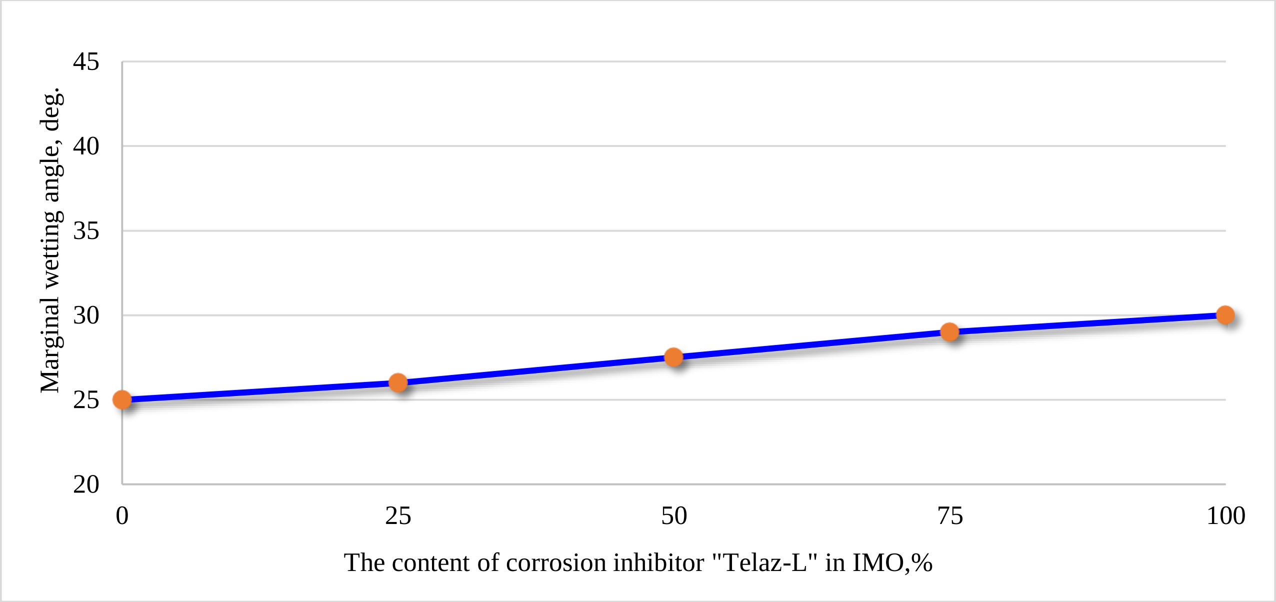

Fig. 1. The effect of the content of corrosion inhibitor in the preservative composition on the edge angle of wetting the surface of the coated sample.

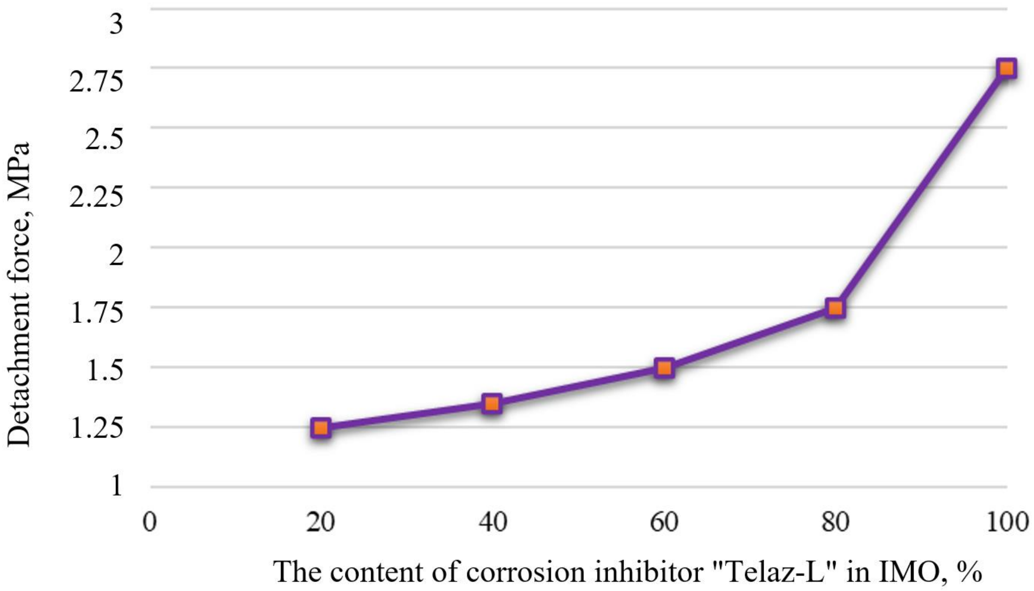

Fig. 2. Influence of corrosion inhibitor content in spent motor oil on the adhesive strength of the preservative composition.

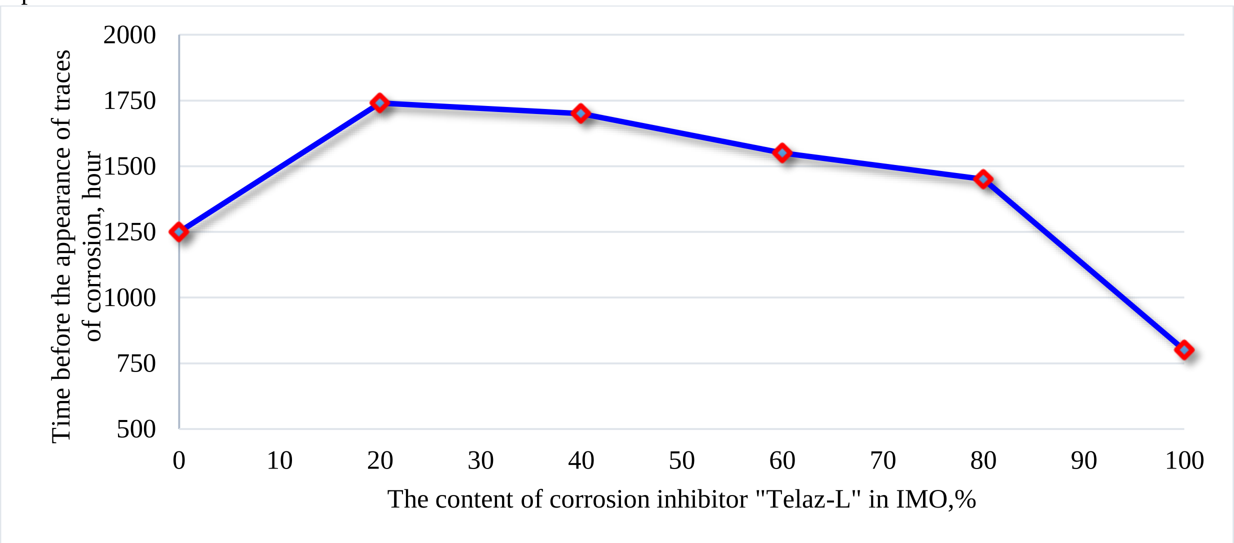

Fig. 3. Influence of corrosion inhibitor content in spent engine oil on corrosion resistance of preservative composition

Studies show that the greatest corrosion resistance of samples is observed in the content in the conservation composition of 20...40% corrosion inhibitor.

The effect of boehmite nanopowder content in spent mineral oils (motor and transformer) on corrosion resistance is shown in Fig. 4.

According to the results of electrochemical studies, it can be concluded that the addition of bemit nanopowder to waste oils reduces the corrosion rate (Table 1).

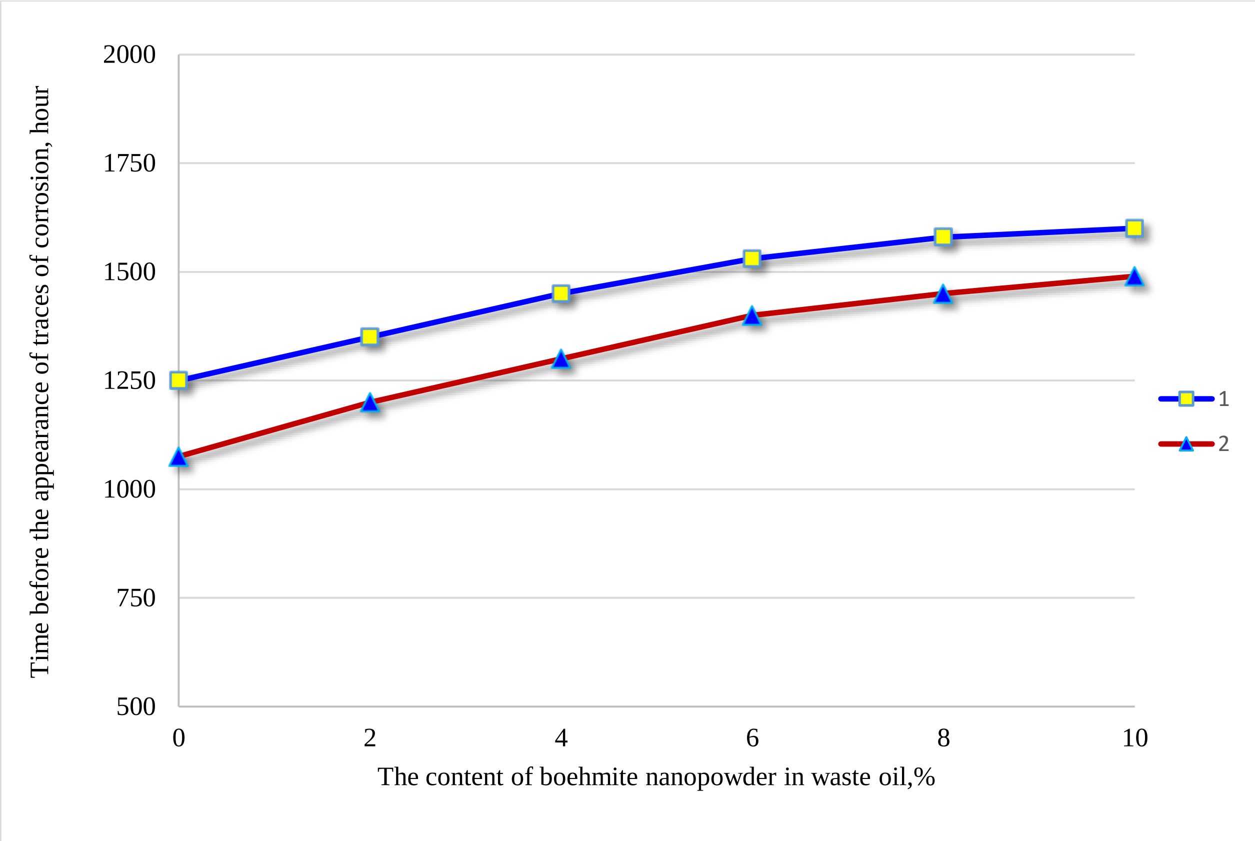

Fig. 4. Influence of boehmite nanopowder content in waste oil on corrosion resistance of preservative composition: 1 – motor oil; 2 – transformer oil

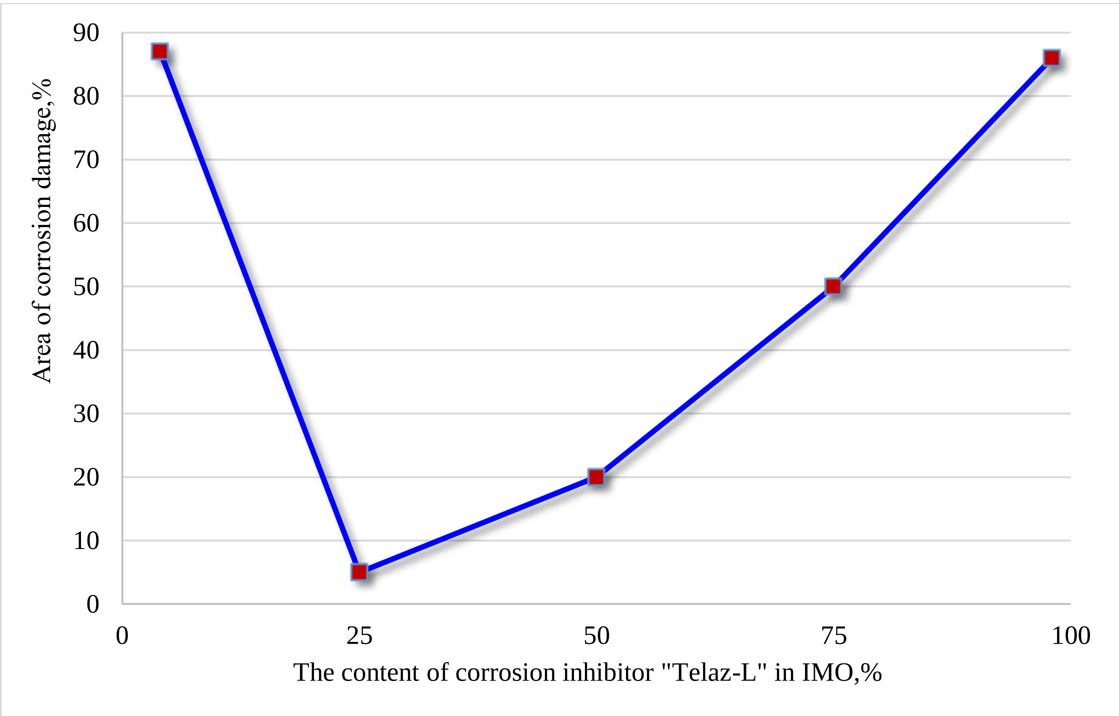

Fig. 5. Dependence of the area of corrosion damage on the content of corrosion inhibitor in spent engine oil

Table 1. The results of electrochemical measurements on steel 3 in 0.5 M NaCl solution

The studied composition	Corrosion current density (i_{kor}), A/m^2	Corrosion rate $K_{e/x}$, g/(m^2 hour)	Protective effect Z,%
Used transformer oil	0.0631	0.0658	-
Spent transformer oil + boron nanopowder (5%)	0.0316	0.0328	50.15
Corrosion inhibitor (20%) + waste engine oil (80%)	0.0002	0.0002	99.69

After 12 months of indoor testing, no traces of corrosion were found on the samples covered with oil production waste. The addition of boehmite nanopowder to waste engine oil also eliminates the appearance of corrosion foci during the year. When stored under a canopy, preservatives based on oil production waste are completely protected from corrosion for 3 months. After 12 months of testing, all samples covered with oil production waste showed minor traces of corrosion. When tested in the open atmosphere, uncoated samples begin to corrode during the first month, after 3 months the area of corrosion foci reaches 20%, and by the end of the year - 95%. Waste motor oil and vegetable oil waste also cannot provide reliable protection of steel surfaces during outdoor storage. After 12 months of testing, the area of corrosion damage is at least 50%, and in some cases reaches 90%. The results of corrosion tests of samples in the open field show that the optimal conservation composition contains 25% corrosion inhibitor "Telaz-L" and 75% spent engine oil. In this case, the area of corrosion damage after 12 months of testing is 5% (Fig. 5).

To determine the protective effectiveness of the developed compositions, tests were performed in production conditions. No traces of corrosion were detected on the surfaces treated with preservatives during storage of the machines.

Conclusions

1. The greatest corrosion resistance of samples is observed for the content in the conservation composition of 20...40% corrosion inhibitor. When bemite nanopowder is added to waste mineral oils, their corrosion resistance increases slightly. The corrosion resistance of the preservative composition is most intensively increased by changing the concentration of boehmite nanopowder in waste oil in the range from 4 to 8%, then its growth slows down. The results of electrochemical studies show that the addition of boehmite nanopowder to waste oils reduces the corrosion rate.

2. The results of tests of corrosion resistance of samples in open areas show that the optimal conservation composition contains 25% corrosion inhibitor "Telaz-L" and 75% spent engine oil. In this case, the area of corrosion damage after 12 months of testing is 5%. With a further increase in the content of corrosion inhibitor in the IMO, the protective ability of the preservative composition deteriorates.

3. The stored indoors after 12 months of testing on samples covered with waste vegetable oil, no signs of corrosion. The area of corrosion foci of samples coated with waste engine oil after 12 months was 5%. The addition of boehmite nanopowder to waste engine oil eliminates the appearance of corrosion foci during the year.

4. During storage under a canopy After 12 months of testing, all samples covered with vegetable oil production waste showed minor traces of corrosion. The area of corrosion foci of samples coated with waste engine oil after 12 months was 8%. When booze nanopowder was added to the spent engine oil, the area of corrosion damage decreased to 5%. When using a composition containing 25% corrosion inhibitor "Telaz-L" and 75% spent engine oil, the area of corrosion damage after 12 months of testing is 2%.

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АЛГОРИТМІЧНІСТЬ ВИЗНАЧЕННЯ ЕФЕКТИВНОСТІ ЗБЕРІГАННЯ ЗЕРНОЗБИРАЛЬНИХ КОМБАЙНІВ

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Анотація. В статті проведено дослідження та узагальнення ефективності зберігання зернозбиральних комбайнів. Найбільш ефективне зберігання машин забезпечується у закритих приміщеннях агропромислових підприємств. Проте близько 60% парку зернозбиральних комбайнів зберігається на відкритих майданчиках. Через обмежені економічні можливості у багатьох організаціях є випадки недотримання правил зберігання машин та низької якості виконання робіт із протикорозійного захисту. Внаслідок корозії при зберіганні машин та обладнання знижується їх довговічність, підвищується трудомісткість операцій технічного обслуговування та ремонту. Найбільш схильні до корозії зуби шестерень і втулково-роликові ланцюги, різьбові з'єднання, робочі органи ґрунтообробних машин: леміхи плугів, лапи культиваторів та інші. Через корозію зростають витрати на утримання парку машин. Витрати на технічне обслуговування та ремонт робочих органів ґрунтообробних знарядь в організаціях становлять від 32 до 78% вартості машин. Останніми роками зниження витрат на протикорозійний захист спостерігається тенденція використання консерваційних складів з відходів. Проте конкретні рекомендації щодо приготування таких консерваційних складів та результати їх випробувань стосовно зернозбиральних комбайнів у літературі відсутні.

Ключові слова: довговічність, ефективність, зберігання, корозія, нанопорошок, мінеральні оливи, ресурсозберігаючі склади.

АЛГОРИТМИЧНОСТЬ ОПРЕДЕЛЕНИЯ ЭФФЕКТИВНОСТИ ХРАНЕНИЯ ЗЕРНОСБОРНЫХ КОМБАЙНОВ

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Аннотация. В статье проведены исследования и обобщение эффективности хранения зерноуборочных комбайнов. Наиболее эффективное хранение машин обеспечивается в закрытых помещениях агропромышленных предприятий. Однако около 60% парка зерноуборочных комбайнов хранится на открытых площадках. Из-за ограниченных экономических возможностей во многих организациях есть случаи несоблюдения правил хранения машин и низкого качества выполнения работ по противокоррозионной защите. В результате коррозии при хранении машин и оборудования снижается их долговечность, повышается трудоемкость операций технического обслуживания и ремонта. Наиболее подвержены коррозии зубья шестерен и втулочно-роликовые цепи, резьбовые соединения, рабочие органы почвообрабатывающих машин: лемехи плугов, лапы культиваторов и другие. Из-за коррозии растут расходы на содержание парка машин. Расходы на техническое обслуживание и ремонт рабочих органов почвообрабатывающих орудий в организациях составляют от 32% до 78% стоимости машин. В последние годы снижение затрат на противокоррозионную защиту наблюдается тенденция использования консервационных составов из отходов. Однако конкретные рекомендации по приготовлению таких консервационных составов и результаты их испытаний по зерноуборочных комбайнов в литературе отсутствуют.

Ключевые слова: долговечность, эффективность, хранение, коррозия, нанопорошок, минеральные масла, ресурсосберегающие составы.

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