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PREVENTION OF CORROSION AND ACCELERATED WEAR OF AGRICULTURAL MACHINERY

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Abstract: The details of the working units of agricultural machines are investigated, the reasons for their accelerated wear are determined. To reduce the rate of general wear, it is proposed to use working and conservation lubricants that protect metal parts from corrosion and have sufficient anti/=wear properties. The properties of used and newly developed lubricants have been studied.
The principle of selection of components for working and conservation lubricants is considered. Laboratory tests of the protective and antiwear properties of lubricants were carried out by standard methods, the mechanism of action of the additives added was established. It was found that the initial corrosion damage 1.5-2 times accelerates the rate of mechanical wear and contributes to the premature replacement of most units. To extend the service life of equipment in the region, the most acceptable is the use of working and conservation lubricants containing corrosion inhibitors and components from vegetable oil waste.

Keywords: agricultural machinery, storage, corrosion, wear, lubrication, corrosion inhibitor.

I. INTRODUCTION:

Prominent scientists of the 80s of the last century, academicians Ya. Kolotyrkin, A. Ishlinsky, B. Paton, L. Antropov, I. Rosenfeld, discussing the problems of science and innovations, repeatedly stressed the need to combat metal corrosion [1-3]. According to their observations and calculations, 10 percent of the smelted metal is irretrievably lost due to corrosion every year, every third piece of equipment is prematurely overhauled, and every year, finance is spent on repairing equipment that exceeds the cost of manufacturing them.

Research in recent years has greatly expanded our understanding of friction, corrosion, and wear and their combined effect. Despite this, the situation has not changed much over the past time and for scientists, mechanical engineers, operators of vehicles and agricultural machinery, the solution of the problems of friction, wear and corrosion is still relevant.

The development of a systematic approach to friction, corrosion and wear has become possible, primarily based on mechanochemistry, electrochemistry, the theory of contact and phase interactions, and the study of the mechanism of action of poorly soluble surfactants (surfactants) added to low-polarity fuels and lubricants.

In various units and assemblies of automobiles, agricultural machinery and other equipment, some types of wear can proceed sequentially or in parallel, one type can change into another, and the combination of different types of wear, as a rule, provides a significant synergistic (negative) effect. So, electrochemical corrosion during storage of cars and other equipment, even in those cases when it does not cause loss of metal mass, and does not give visible corrosive damage, deteriorates the functional properties of surfaces of friction pairs and prepares them in the future for intense deformation-adhesive, abrasive, hydrogen, corrosion-mechanical and other types of wear during friction and vibration.
In general, you can write:

$$I_{gen}=\Sigma\Delta I=\Delta M+\Delta ChC+\Delta PCh+\Delta EC=\Delta A+\Delta E+\Delta C+\Delta E_{Hg}+\Delta O+\Delta S+\Delta F+\Delta F_{c}+\Delta F_{chp}++\Delta H+\Delta FC+\Delta CF$$
$$+\Delta FrC+\Delta AtC+\Delta AC+\Delta CC+\Delta EP+\Delta CrC+\Delta ESC+\Delta ITC+\Delta HEC+\Delta SCC$$

where: I - general wear and tear;
Δ- is the share of certain types of wear;
M - Mechanical adhesive wear;
ChC - Chemicalcorrosion;
PCh - Physical (mechanical) and chemical wear;
EC - Electrochemical corrosion;

A - Abrasive, hydro-gas-abrasive;
E – Electroerosive;
C – Cavitational;
E_{Hg} - Erosive, Hydro-gas-erosion;
O – Oxidizing;
S - When seizing;
F – Fretting;
F_c - Fatigue (cyclic) wear;
F_{chp} - Fatigue Chipping-Pitting;
H - Hydrogen wear;
FC - Frictional corrosion;
CF-Corrosion fatigue wear;
FrC - Frettingcorrosion;
AtC - Atmospheric corrosion;
AC - Acid corrosion;
CC - Contact corrosion;
EP - Electrochemical pitting;
CrC - Crevice corrosion;
ESC - Exfoliation and subsurface corrosion;
ITC - Intergranular and transcrystalline corrosion;
HEC - Hydrogen embrittlement corrosion;
SCC - Stress corrosion cracking.

The object of our research was primarily oil products and components with energy and surface characteristics in the oil-metal-electrolyte-surfactant-air system.

The efficiency of any enterprise directly depends on the reliability of the equipment used. Agricultural production is no exception, but on the contrary, varied, very expensive seasonally used equipment breaks down much earlier than a permanent car.

The reason is all the same problems of corrosion, wear, conservation, de-conservation, lack of financial and human resources to meet the requirements of storage rules according to GOST 7751-2009.

The Central Asian region is characterized not only by high solar radiation and high dust content in the air but also by large fluctuations in temperature during the day, high humidity in the autumn-winter period, year-round storage of equipment in open conditions.

II. Materials and methods:

Inspection of the equipment was carried out with a visit to the agricultural clusters of the Tashkent and Syrdarya regions. The degree of implementation of the conservation operation was provided for following GOST 7751-2009, and their effectiveness was assessed by questioning the specialists in the operation of equipment.

Tests of petroleum products were carried out using standard (protective properties according to GOST 9054-75, lubricating properties according to GOST 9490-75) and generally accepted methods.

The mechanism of protective action was assessed by water displacement and changes in the contact potential difference of the metal (ΔCRP), the penetrating and impregnating ability according to the methods of the All-Russian Research Institute of Oil Refining Joint Stock Company (VNIINP JSC).

III. Results:

The Central Asian region is characterized by large daily temperature fluctuations, high content of aggressive dust in the air. Although the region is distinguished by the cultivation of cotton, almost all areas of agriculture are developed here and thousands of cotton and grain harvesters, hundreds of thousands of cultivators and other periodically operated equipment are widely used.

Our studies showed that most of this technique was used for 15 to 30 days a year, and was idle the rest of the time. During the write-off period, the equipment does not work out in time even 0.5 calendar season.

Despite this, there are high costs for spare parts every year, engines and power units have time to undergo major repairs. Large financial and labor resources are spent on maintaining the equipment.

Familiarization with the work of grain harvesters showed that every year almost half a million running meters of chains are purchased for them abroad.

Chains, like most working parts of equipment, are subject to intense corrosion as a result of open storage. The consequence of corrosion significantly accelerates the mechanical wear of rubbing parts. At the same time, the rust itself acts as an abrasive, and the weakened surface of the metal crumbles and the rate of wear increases by an order of magnitude.

Table 1 summarizes information from various publications and the results of our observations.

Table 1

Types of corrosion and corrosion-mechanical destruction of parts

Typesofdestruction	**Units and parts of machines subject to destruction**	**The nature of the destruction**	**Causesofdestruction**
Atmospheric corrosion	All metal products that do not have protective coatings	The formation of oxidizing films with subsequent peeling and the appearance of foci of uniform or pitting corrosion, leading to metal losses up to 250-300 g / m2 per year, a decrease in strength by 30-40%, and a decrease in wear resistance by 1.5-2 times.	The action of atmospheric precipitation, humid air, temperature, aggressive impurities, etc.
Corrosion-mechanicalwear	Sleeves and pistons of engines, sprockets, chains, pulley grooves, parts of cutting devices, casings of conveyors, augers, etc. bottoms and friction surfaces on machine casings	The appearance on the friction surfaces of corrosion and mechanical damage in the form of stripes, marks, spots, etc., leading to a decrease in the wear resistance of the metal by 1.5-2 times	The action of a corrosive environment and continuous destruction of the oxide film at the points of moving contact
Corrosionfatigue	Axles and shafts, frames, frames, thin-sheet structures, sleeve-roller and hook chains, gears and spline joints, rolling bearings, springs, etc.	Corrosion fractures, cracks and metal breaks resulting from a decrease in fatigue strength by 30-40%	The action of a corrosive environment and alternating loads
Stresscorrosioncracking	Fasteners and welded joints, parts subject to assembly and weight loads, long-dimensional parts, etc.	Corrosion cracks resulting from a decrease in the statistical strength of the metal by 1.5-2 times	Corrosive environment and static stress action

Machine parts that are not protected before storage may become unusable even during non-working hours. At the same time, cars are adversely affected by precipitation in the form of rain, dew, fog, sleet, as well as humid air, particles of fertilizers, dust and soil, juices from plants, etc. aggressive substances.

Significantly enhances corrosion, daily temperature fluctuations, leading to the formation of a wet zone in the spaces of the gaps. As a result of this, on the surfaces of the rubbing parts, and the surfaces of all other parts, aqueous solutions of the particles of mineral fertilizers deposited there are formed.Most of the fertilizers used in cotton-growing areas are acidic and this enhances the occurrence of chemical and electrochemical corrosion. So research has found that the loss of steel in ammonium nitrate is 550-600 g/m^2 per year.

Slightly less, but still practically up to 500 g/m^2 per year, the loss of metal comes in contact with superphosphate and potash fertilizers. A particular danger is the constant contact of metalworking bodies of cultivators, plows and other equipment with soil saturated with solutions of mineral fertilizers. Research has established that the corrosion rate in aqueous solutions is 5.0-10.2 mm/year. The above examples show the importance of solving the problems of corrosion protection of machines in contact with soil and mineral fertilizers.

The most widespread is still the coating of the surfaces of equipment with paints and varnishes, but their use in working bodies is not acceptable due to the instability of their abrasive wear. As a rule, the service life of agricultural machines is often limited to six or seven years, it is considered that further operation is not economically profitable, since requires a lot of spare parts and overhaul of equipment.

To protect the main assemblies and parts, and working bodies, the most acceptable, both from an economic and a technological point of view, is lubricants and their new compositions. First, they protect rubbing parts from mechanical wear, and second, when optimizing their compositions, they can simultaneously play the role of anti-corrosion and anti-wear material

The protective effect of oil-soluble corrosion inhibitors and inhibited lubricants have the following aspects:

- Displacement of water from the metal surface upon contact of the metal with the product;
- Formation of chemisorption and adsorption films of corrosion inhibitors on the metal;
- Opening of the electrochemical corrosion circuit;
- Formation of a protective film layer under the influence of the forces of adhesion and cohesion;
- Complete isolation of the metal by the formed protective layer;
- Refinement of aqueous media due to water-soluble components of the protective composition.

Table2

Results of studies of selected lubricants before and after adding 5% corrosion inhibitors to them

Lubricants	Commoditymaterials					Commoditymaterials + 5% corrosioninhibitor				
Lubricantindicators	Movil	Solidol	Litol-24	Freshengineoil	Wasteoil	Movil	Solidol	Litol-24	Freshengineoil	Wasteoil
Protective properties (GOST 9.054-75):% of the surface affected by corrosion, Steel 10, in a thermal moisture chamber G-4, 600 hours	0	26	6	40	80	0	14	2	8	56
When immersed in "seawater", 300 hours	0	24	10	4	75	0	12	2	6	25
Water displacement (5% in oil M-6), the diameter of the circle freed from water, after 5 minutes.	80	6	22	10	18	112	9	36	14	20
Penetration capacity in micro-gap, mm	40	4	12	16	15	44	8	28	20	18
Impregnation capacity (iron oxide), mm	8	3	5	16	18	18	6	17	24	18
Antiwear properties on a four-ball friction machine (GOST 9490-75), wear scar diameter, mm	3,5	0,9	0,72	0,4	0,8	3,2	0,9	0,74	0,42	0,8
Change in the contact potential difference of the steel electrode, ΔKRP, mV	+60	+20	+48	+40	+10	+120	+80	+160	+120	+50

We are working on inhibition of the main types of technical fluids and lubricants used in periodically operated equipment.

When using working and conservation materials, there is no need to perform a large amount of disassembly and assembly work, additional lubrication operations before putting it into operation.

The most important use of inhibited lubricants will undoubtedly reduce the overall wear of mechanisms and, as a result, will ensure durable and reliable operation of both machines and agricultural implements.

IV. CONCLUSION:

Based on the tests performed, the following conclusions can be drawn:

– Most of the specialized agricultural machinery is used within a year for no more than a month, the rest of the time is stored and idle in open areas;

– Due to the lack of necessary materials, as well as due to the technological complexity of operations, off-season conservation of equipment is practically not performed;

– Under the influence of moisture, atmospheric precipitation, dust, residues of mineral fertilizers, the surfaces of critical parts are subject to corrosion and subsequent increased mechanical wear;

– In the conditions of the Central Asian region, the most expedient is the use of working and conserve fuel and lubricants and technical fluids that have a protective and sufficient level of other performance properties;

– Transfer of agricultural machinery to working and conservation materials, preventing corrosion and mechanical wear of critical parts, contributes to an increase in service life by 1.5-1.8 times.

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