

The mechanical life of implements operating in corrosive service

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Abstract. In severe operating conditions, there are machines for the preparation and introduction of mineral and organic fertilizers, herbicides, pesticides. They fail in order after two or three years due to corrosion and corrosion-mechanical wear. Under these conditions, the main thing is not to protect individual details, but the protection of the machine as a whole. Disclosure of the mechanism and patterns of corrosion-mechanical wear and corrosion of structural materials in aggressive environments made it possible to scientifically substantiate the most effective ways to increase the service life of machines at the stages of design, manufacturing and operation. Passive working bodies (frame, body, tank) polymer and gummed coatings are reliably protected from corrosion. Corrosion damage to the details of agricultural machines during storage. The illustrated surfaces of the working bodies of plows, seeders, cultivators, disk harrows and other agricultural machines in the storage period are oxidized and coated with rust. In some cases, it appears due to the destruction of the protective film of paint in others - due to violation of the storage rules. The lower parts of agricultural machines made of simple carbonistic structural and unfounded steels, in contrast to parts remote from the soil and no contact with it, corroded intensively.

1 Introduction

Corrosion damages component parts of the implements during storage. Unpreserved surfaces of the working tools of plows, sowing drills, cultivators, disc harrows and other implements are oxidized and incrust. Contamination on component parts increases corrosion, because in combination with damp, they can create an active electrochemical environment that causes intense corrosion processes. First of all, corrosion damages the exposed surfaces. In some cases, it is caused by the paint degradation (during transportation, work, etc.), in others by incorrect storage. The lower parts of the implements (shares, lower track wheels, transport wheel, etc.) made of simple carbon structural and low-alloy steels, compared to component parts that do not contact with soil, corrode more intensively [1,8,14]. The depth of damage of some component parts reaches intolerably large sizes. So, if axles, seed boxes, protective covers, frames are damaged to a depth of

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0.02 ... 0.07 mm in a year, then parts of working tools and supporting parts, contacting with the soil – 0.42 ... 0.44 mm.

Corrosion is most dangerous for assembly component parts operating under cyclic or impact loads (springs, spring hoes, axles, shafts, etc.). The mechanical life of parts is very often reduced by 40 80% because of fatigue fractures in practice. In examining fractures, parts (cultivator shares, shafts, etc.), it has been found that pitting corrosion sets the beginning of many fractures.

Deterioration is a change of the physicochemical properties of materials during their service as time passes. This is because of the destruction processes, that is, the molecular decomposition of the backbone chain.

2 Results and discussion

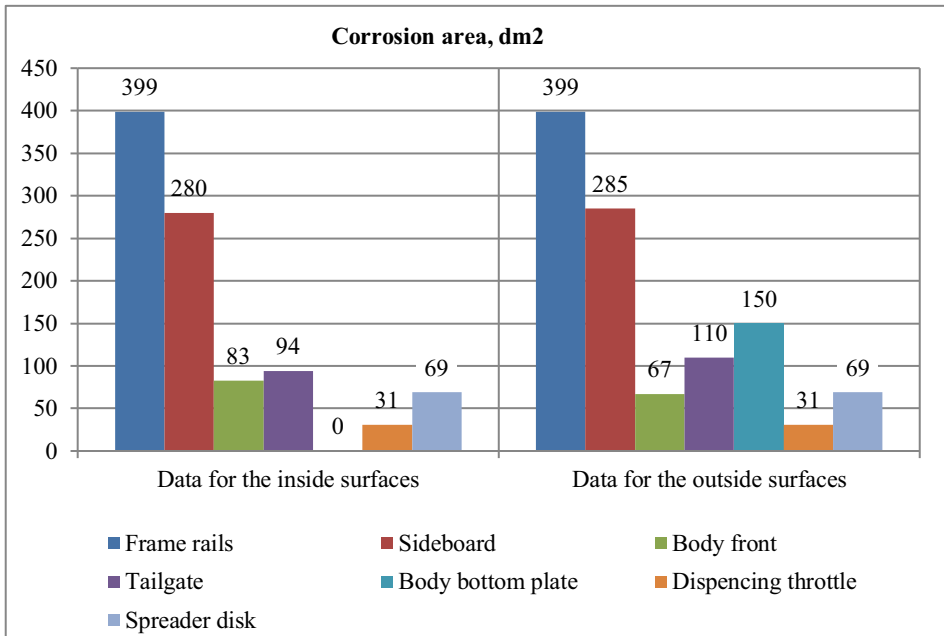
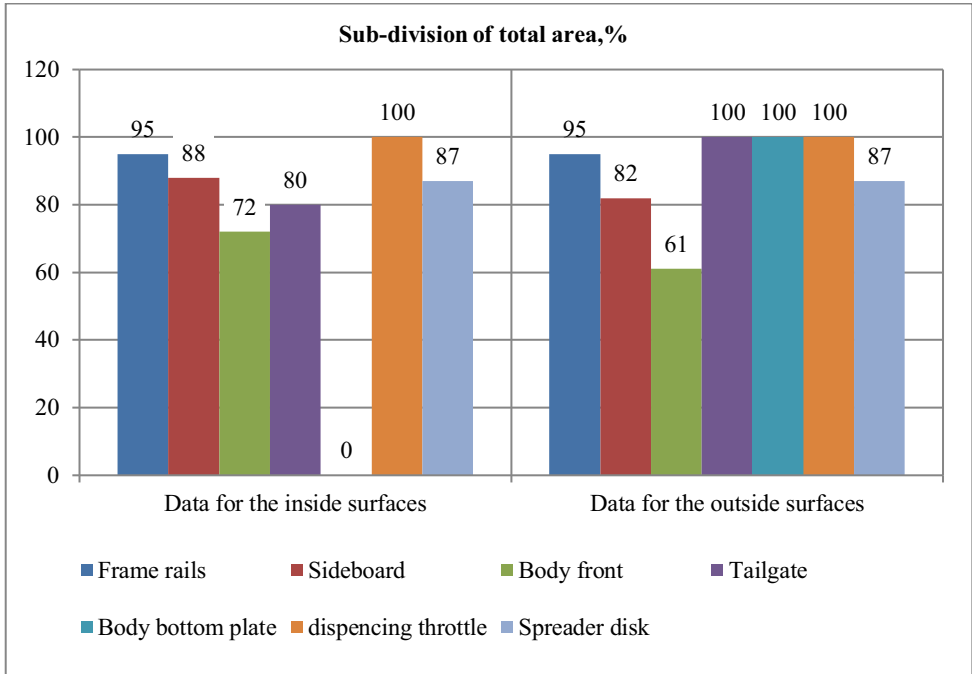
The most common method of anticorrosion protection of the implements' outside surfaces in preparing them for storage is a preservation of them with various protective materials. For these purposes, viscous lubrication, conservation oils and greases, protective wax dispersions, film-forming inhibited petroleum compositions, gasoline-bituminous compositions, oil-soluble and anticorrosive additives are used. The main criteria for the selection of preservation materials are the corrosiveness of the environment, the way of storage, the condition of the protected surface, the duration of protection, the application process and the need for depreservation [2,9,15].

Materials based on liquid rubber are advanced for protecting implements from corrosion and mechanochemical wear. The wear and corrosion resistance in mineral fertilizers of rubberized coats based on polychloroprene NT and their compositions with various fillers have been studied [3,5,13].

Rubbers have a special place among polymeric materials due to their high elasticity. Rubber coatings resist abrasion. The research results show that the volumetric wear of the rubberized coats in comparison with steel St3 in free running mineral fertilizers is less by almost 25%.

Table 1. The corrosion area of the mineral fertilizer spreader's component parts 1RMG-4 (after two years of service).

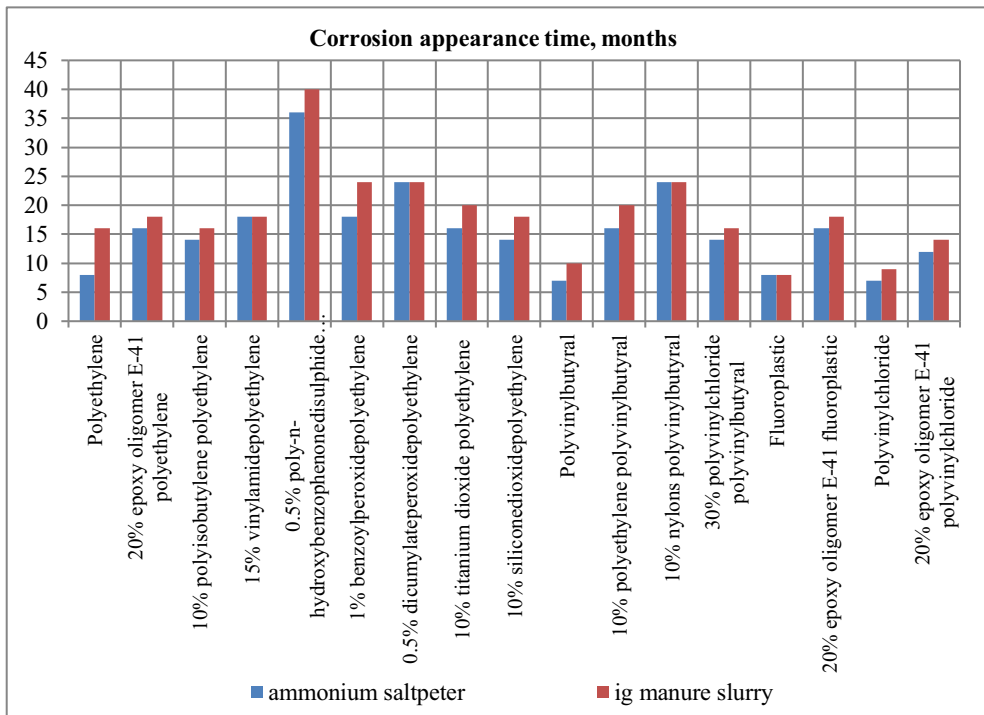
Component parts	Corrosion area, dm ²	Sub-division of total area, %
Frame rails	399	95
Sides:		
sideboard	280/285	88/82
body front	83/67	72/61
tailgate	94/110	80/100
Body bottom plate	0/150	0/100
Dispensing throttle	31/31	100/100
Spreader disk	69	87
Note. In the numerator - data for the inside, in the denominator - for the outside surfaces		



It is necessary to use additives of various ingredients (flexibilizers, antideteriorants, fillers, etc.) to improve the protective properties of polymeric coatings. As Table 2 shows, coatings made of polyethylenewith poly-*n*-hydroxybenzophenonedisulphide, dicumyl and benzoyl additives have the best protective properties.

Table2. Protective ability of polymer coatings.

Coating	Corrosion appearance time, months	
	ammonium salt pter	pigmanure slurry
Polyethylene	8	10
20% epoxy oligomer E-41 polyethylene	16	18
10% polyisobutylene polyethylene	14	16
15% vinylamide polyethylene	18	18
0.5% poly-n-hydroxybenzophenonedisulphide polyethylene	36	40
1% benzoylperoxide polyethylene	18	24
Полиэтилен с 0,5% перекиси дикумилата 0.5% dicumylate peroxide polyethylene	24	24
10% titanium dioxide polyethylene	16	20
10% silicon dioxide polyethylene	14	18
Polyvinylbutyral	7	10
10% polyethylene polyvinylbutyral	16	20
10% nylons polyvinylbutyral	24	24
30% polyvinylchloride polyvinylbutyral	14	16
Fluoroplastic	8	8
20% epoxy oligomer E-41 fluoroplastic	16	18
Polyvinylchloride	7	9
20% epoxy oligomer E-41 polyvinylchloride	12	14



The wear resistance of hardened steels has been studied during friction in the mass of mineral fertilizers using an impeller installation. The impact of the corrosion factor has been obtained by comparing the wear rate in two regimes of friction – continuous and intermittent, at intervals: 30 min – stop, 1 min – friction. The fertilizer corrosiveness

$$C_{fr} = \frac{(J_i - J_c)}{J_i} \quad (1)$$

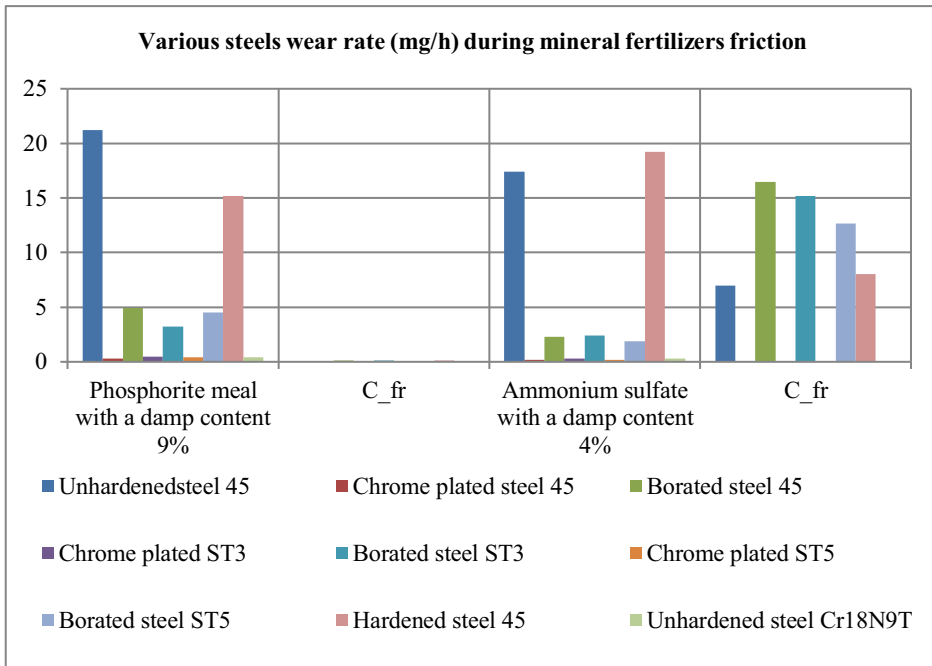
where J_i, J_c – wear rate at intermittent and continuous friction.

The wear resistance of borated and especially chrome-plated steels is much higher than unhardened and hardened ones (table 3). The wear resistance of chrome-plated steels is approximately equal to that of Cr18N9T stainless steel [4,7,11]. The less wear resistance of borated steels as compared to chrome-plated steels is explained by the fact that a grid of microcracks forms on their surface, in the borated layer, which splits during friction, and the corroding medium penetrates through them to the base metal.

Table 3. Various steels wear rate (mg/h) during mineral fertilizers friction

Type	Phosphorite meal with a damp content 9%	C_{fr}	Ammonium sulfate with a damp content 4%	C_{fr}
Unhardened steel 45,	21.2/22.9	0.08	17.4/138.7	6.96
Chrome plated steel 45	0.3/0.3	0.00	0.2/0.2	0.00
Borated steel 45	4.9/3.4	0.10	2.3/40.3	16.50
Chrome plated ST3	0.5/0.5	0.00	0.3/0.3	0.00
Borated steel ST3	3.2/3.5	0.10	2.4/38.8	15.18
Chrome plated ST5	0.4/0.4	0.00	0.2/0.2	0.00
Borated steel ST5	4.5/4.9	0.09	1.9/26.0	12.69
Hardened steel 45	15.2/17.1	0.12	19.2/173.2	8.02
Unhardened steel Cr18N9T	0.4/0.4	0.00	0.3/0.3	0.00

Note. The numerator contains data for continuous friction, in the denominator for intermittent one



There has been no wear recorded in testing the dippers of the 1RMG-4 spreader working disks hardened by thermodiffusion chromizing after 500 hours of service.

Storage period is an important reserve for increasing the mechanical life of implements operating in corrosive environments. For liquid inhibited greases unlike stiff ones, the determining factor is not the permeability of the electrolyte through the coating film, but the

adsorption-chemisorption properties, the presence of which is proved by the aftereffect, i.e. stainlessness after degreasing. Moreover, the protective effectiveness of liquid inhibited oil-based thin-film coatings is due to a semi-solid film that forms during the solvent evaporation by the action of adhesive cohesive forces [6,12].

The protective ability of a bituminous coating increases after adding an inhibited lubricant into it. Anodic and cathodic polarization of samples coated with a mixture of bitumen and NG-204U occurs much faster than when they are coated only with bitumen. This is due to the good conditions for the formation of chemisorption protective films if an inhibited product is included. A mixture consisting of 85 ... 90% bituminous grout and 10 ... 15% inhibited grease is optimal.

3 Conclusion

Silica sand as a filler, has a great influence on the wear of rubberized coats based on polychloroprene NT. The minimum wear is at a content (35 ... 40%). The performance tests of the 1RMG-4 spreader's rubberized parts have showed that their service life is 8 ... 10 times longer than that of the batch ones. Surface alloying during thermochemical treatment gives the best results in increasing the wear resistance of structural steels. Chromium and boron have been chosen from a large number of different elements for the study that can form diffusion coatings. First, chrome-plated and borated surfaces have abrasion and rust resistant. Secondly, diffusion chromium plating and borating are relatively widespread. The hard thermal diffusion chromium plating and borating of St3, St5 and Steel 45 have been used. The composition of the saturating mixture for chromium plating (% of the received mass): 40 - aluminum oxide, 52 - chromium oxide and 8 - aluminum powder. To activate the process of diffusion saturation, 2% of ammonium chloride (to the total mass) has been added. The duration of the process is 8 h, temperature is 1050 ° C.

The composition of the saturating mixture for borating (%): 80 – aluminum oxide, 14 - boron oxide and 6 – aluminum powder. To activate the process, 2% sodium fluoride has been added. Duration of the process is 6 h, temperature is 920 ° C. It is most expedient to use conserving materials on farms prepared on the basis of used engine and gear-box oils with the addition of special inhibited materials. Equipment for liquid complex fertilizing is reliably protected against corrosion by sacrificial inhibitory protection.

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