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THE EFFECT OF NAIRIT COATINGS ON CYCLIC STRENGTH OF SAMPLES AND PARTS SUBJECT TO FRETTING CORROSION

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ABSTRACT: Coating the mating surfaces of metal parts with Nairit is a new and promising method of preventing fretting corrosion. Nairit is a variety of synthetic rubber which can be applied by simple industrial processes. Comparative tests made on Nairit coatings showed them to be superior to any other protective method used up until now. The article includes results and methods of testing for steel and aluminum parts. By preventing fretting corrosion caused by friction, cyclic strength of components is greatly increased.

NOTICE

Cyclic strength of real structures depends on a whole series of operational factors, one of which is contact friction, or fretting corrosion. Fretting corrosion is a special type of damage to metallic parts which occurs in contact areas under load during very low reciprocal movement. The presence of fretting corrosion often leads to premature fatigue breakdown of the part, under stresses which are considerably less than the fatigue point.

The protection of mating parts from damage by fretting corrosion is very complex because up until now a strictly scientific approach to solving this problem has not been worked out. At the present time in industry, liquid and solid lubricants on a base of molybdenum disulfide, various galvanized coatings of a cadmium plating type, phosphating and chrome plating, brass plating, all types of cladding etc. are being used to protect mating surfaces of parts from fretting corrosion [1--4]. However, these coatings do not have adequate effectiveness, liquid lubricants are extruded, and the solid, at significant specific loads wear out in a relatively short time, the contacting surfaces are stripped, after which the process of fretting corrosion begins

The use of various types of packing is a fairly effective method of protecting the contacting surfaces, but it is not very suitable for high load components.

Research was done on Nairit coatings for the purpose of more effective protection of mating surfaces of parts from damage from fretting corrosion during cyclic load.

Nairit is a variety of synthetic rubber. The rubber composition is a 50--70% solution of a rubber mixture on a base of liquid nairits. Nairit has good adhesion to the surface of metal over a chlorinated Nairit primer; the stress of breaking away metallic surfaces glued with Nairit reaches 40--50 kgf/ cm^2, and moreover, Nairit coatings have good resistance to wear, cavitational disintegration and erosion [5]. An important property of Nairit coatings is the fact that they make it possible to increase by 15--20% the cyclic strength of metals [6]. All these positive properties of Nairit coatings lead one to suppose that Nairit can be successfully used for protecting mating surfaces of parts from damage from fretting corrosion. The possibility of using a Nairit coating as the protective material is also facilitated by the fact that the production processes of applying Nairit are simple; and the thickness of Nairit coatings can be very small, on the order of 50--100 microns, which is very important because most contacting parts have very small clearance.

Initially, comparative testing for fretting corrosion was done on special equipment with samples made of 40KhNMA steel, thermally treated to a hardness of $R_c = 36 \div 37$. The contact surface of the samples was polished to a smoothness of $\triangle$ 9.

Three types of samples were tested: with contact surfaces not protected and protected with a lubricant on a base of molybdenum disulfide and on a base of Nairit. Application of the Nairit coating was done in the following way. On one of the contact surfaces, preliminarily degreased with gasoline, chlorinated Nairit primer was applied by spraying. After air drying for an hour liquid Nairit was sprayed on this surface, after which it was vulcanized at a temperature of 100° for 10 hours. Then on the vulcanized surface, a new layer of Nairit was sprayed and again vulcanizing was done etc. It was necessary to apply 5 to 6 layers of Nairit coating to obtain a thickness of 100 microns.

A lubricant on a base of molybdenum disulfide was applied by the following method: finely ground powdered molybdenum disulfide was mixed with epoxy resin brand EP074 in a ratio of 1 part of resin to 2 parts of MoS_2. With the use of a solvent the mixture was brought to the necessary viscosity, after which a layer of the lubricant was applied to a previously phosphated contact surface with a sprayer. Then the sample was held with thermostat control at 200° for an hour for polymerization of the lubricant. The thickness of the coating obtained is 10--15 microns.

Figure 1 shows the results of testing these samples for fretting corrosion; it is apparent that under conditions of contact friction on the samples whose contact surfaces were protected by Nairit, after 144,000 cycles one did not observe any corrosion, and at the same time on samples protected by a molybdenum sulfide base lubricant, fretting corrosion was observed after just 28,000 cycles of movement.

The next stage was studying the protective effect of Nairit coating from fretting corrosion under cyclic load conditions. Fatigue testing was done for this on flat samples with a thickness 0.8 mm made of 1Kh18N9 steel, not protected and protected with Nairit. After quenching in water at 1100°, the mechanical properties of 1Kh18N9 steel were the following:

σ_b = 64.5 kgf/mm^2, $\sigma_{0.2}$ = 34.1 kgf/mm^2 and δ = 67%.

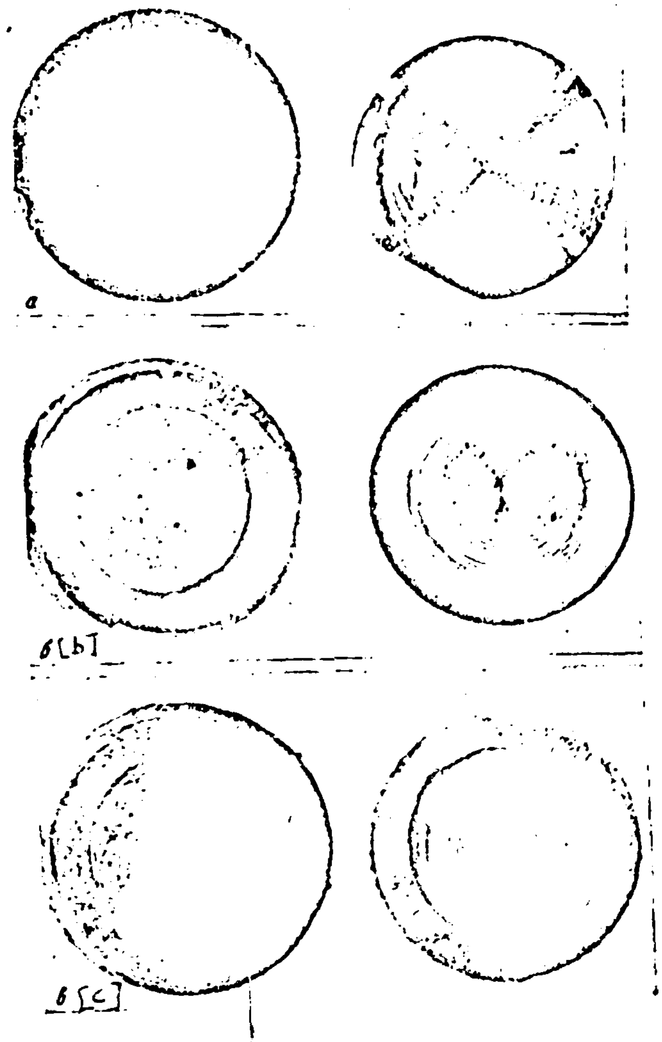

Figure 1. Contact Surfaces of Samples Made of 40KhNMA Steel After Testing in Contact Friction Conditions Under a Load of 200 kgf/cm^2 and Separation 0.05 mm.

a--Unprotected surfaces, N = 21,500 cycles; b--Surface protected with a lubricant on a base of MoS_2, N = 28,000 cycles; c--Surfaces protected with Nairit, N = 144,000 cycles.

The method described in work [7] was used for creating contact friction in the sample sections liable to the greatest stress.

Figure 2 shows the results of fatigue tests fiom which it is apparent that samples coated with Nairit and tested under conditions of contact friction, have approximately the same fatigue strength as analogous samples which are tested under conditions which exclude the formation of fretting corrosion, and considerably greater fatigue strength than non-coated samples tested both under cunditions of frecting corrosion, and under conditions which exclude its formation. On the surfaces of the samples not coated with Nairit, there are turbulent spots which are characteristic for fretting corrosion, at the same time that on samples coated with Nairit and also tested under fretting conditions, in the area of contact with a clamp, there were considerably fewer traces of friction from the clamp on the coating.

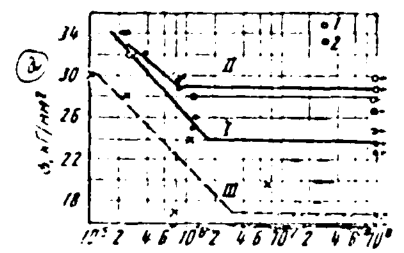

Figure 2. Fatigue Curves for 1Kh18N9 Steel

I--For samples without coatings, tested under conditions which exclude the formation of fretting corrosion;
II--For samples with Nairit coating;
1--Tested under conditions which exclude the formation of fretting corrosion;
2--Under fretting corrosion conditions;
III--For samples without coatings tested under fretting corrosion conditions

Key: a. kgf/mm^2

Therefore, tests on laboratory samples showed great promise for the use of Nairic coatings for protecting contacting surfaces from fretting corrosion damage.

Because of this, full scale test stand tests were made on a number of parts which are subject to high damage from fretting corrosion during operation. The use of Nairit coatings for protecting mating surfaces of these parts also gave very positive results.

Seven components (nozzle) underwent full scale testing to disintegration on the test stand. Figure 3 shows the attachment of such a component with the connecting part on the test stand and a diagram of the load. Two test pieces--nozzles were attached to the connecting part with bolts from two sides. The nozzle and the connecting part were made from 40KhNMA steel thermally processed to a hardness of $R_c = 31 \div 37$, the mating surfaces were processed to a smoothness of ∇ 7.

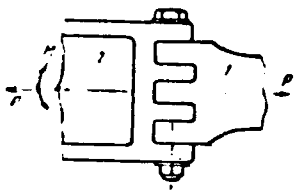

Figure 3. A Diagram of the Attachment and Load on the Test Unit for the Connection of the Nozzle (1) and the Connective Part (2)

Tests were carried out for static stretching of the unit equal to 20 tons, with simultaneous application of alternating momentum $M = \pm 300$ kgm with frequency load 675 cycles per minute. Fatigue disintegration of the parts after test stand tests occurred along the air hole as a result of strong disintegration from fretting corrosion of the coupled surfaces. Maximum treatment of the these parts before disintegration reached 31.5×10^6 cycles. Figure 4 shows the air hole of the nozzle, damaged by strong fretting corrosion, and Figure 5--the fatigue fracture of this same air hole. The disintegration of the airhole has a fatigue character but the fatigue crack runs first from a section damaged by fretting corrosion.

Three analogous nozzle components were coated on the surfaces of the airhole with a Nairit coating with a thickness 50--100 microns before test stand tests. The tests were made analogously to the four preceding components. After operation on the test stand of more than 45×10^6 cycles, these components

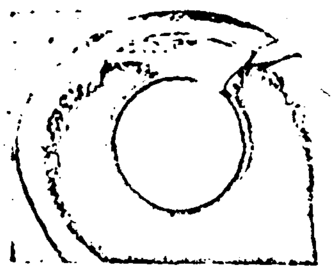

Figure 4. An Airhole of a Nozzle Damaged by Strong Fretting Corrosion

Figure 5. Fatigue Fracture of an Airhole Damaged by Fretting Corrosion. The arrow points to the center of the beginning of development of the fatigue crack.

were removed from testing without disintegration. On the mating surfaces of these three nozzles no fretting corrosion development was observed.

In addition to full-scale testing of nozzles, stand testing of other parts was done--of a beaker made of 18Kh2N4A steel thermally processed to a hardness of $R_c = 35 \div 41$. The part mated to it was made from aluminum AVT1 alloy. The finish of the mating surfaces on the parts was ∇ 7. The following two units were tested: those with contacting surfaces protected by a Nairit coating and those without Nairit protection. In the first case, the beaker was run on the test stand for 220×10^6 cycles before disintegration, and on the contacting surfaces of the beaker and the aluminum part, traces of fretting corrosion were practically nonexistent; at the same time this same beaker without the Nairit coating was tested for 56×10^6 cycles before disintegration and on its contacting surfaces there were sections damaged by intense fretting corrosion, evident centers of the origin and development of a fatigue crack.

Such a positive effect of Nairit coatings on the increased fatigue strength of parts is explained by the fact that these coatings which have good adhesion to metal are elastic, with the packing between the two mating surfaces not disintegrating during operation. Therefore, there is no friction of one metallic surface on another. This eliminates the development of physical and chemical processes which occur during contact of two mating parts.

Therefore, it is apparent that Nairit coatings reliably protect mating surfaces from damage by fretting corrosion, thus facilitating an increase in cyclic strength of components.

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