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EFFECT OF NEOPRENE COATINGS ON THE CYCLIC FATIGUE OF SPECIMENS AND PARTS SUBJECTED TO THE ACTION OF FRETTING-CORROSION

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В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

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GRAPHICS DISCLAIMER

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RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

EFFECT OF NEOPRENE COATINGS ON THE CYCLIC FATIGUE OF SPECIMENS AND PARTS SUBJECTED TO THE ACTION OF FRETTING-CORROSION

V. S. Ivanova and M. G. Veitsman

The cyclic fatigue of real structures depends on a whole series of operating factors, one of which is contact friction, or fretting corrosion. Fretting corrosion — this is a special form of damage of metal parts, which originates in places of contact under stress, in the presence of very small reciprocal motion. The presence of fretting corrosion often leads to premature fatigue failure of the part under stresses significantly below the endurance limit.

The protection of coupled parts from attack by fretting corrosion is very complex, because up to now no strictly scientific approach to the solution of the given problem has been developed. At present, liquid and solid lubricants based on molybdenum disulfide, different galvanic coatings of cadmium plating, phosphate plating, chrome plating, and brass plating, various linings, etc., are used in industry for the protection of coupled surfaces from fretting corrosion [1 - 4]. However, these coatings do not possess sufficient effectiveness; liquid coatings are pressed out and solid coatings are worn away under appreciable stresses after a relatively short period of time; contacting surfaces are denuded, after which the process of fretting corrosion is initiated. The use of different linings is a fairly effective method of protecting contacting surfaces, but it is not good enough for highly stressed joints.

Neoprene coatings were studied with the objective of obtaining more effective protection of coupled surfaces from attack by fretting corrosion under conditions of cyclic loadings.

Neoprene is a variety of synthetic rubber. The gum-forming composition is a 50 - 70% solution of a rubber stock based on liquid neoprenes. Neoprene possesses good adhesion to the surface of the metal through a chlorneoprene prime coat; the breakaway stress of metallic surfaces cemented by neoprene is 40 - 50 kg/cm^2, and, besides, neoprene coatings have good resistance to wear, cavitation failure, and erosion [5]. An important property of neoprene coatings is that they permit a 15 - 20% increase in the cyclic strength of metals [6]. All these advantages of neoprene coatings led us to assume that neoprene can be used with success for the protection of coupled surfaces from attack by fretting corrosion. The possibility of using neoprene coatings to protect a material is dependent on the fact that the technology of applying neoprene is simple, and the thickness of the neoprene coating can be very small, on the order of 50 - 100 μ, which is very important because the majority of coupled parts have a small clearance.

Comparative fretting-corrosion tests were conducted on 40KhNMA steel specimens, heat treated to a hardness of R_c = 36 - 37, using primarily a special apparatus. The contact surfaces of the specimen were polished to a smoothness of ∇ 9.

Three forms of specimen were tested: with contact surfaces not protected, or protected by a molybdenum-disulfide base, or by a neoprene-base lubricant. Application of the neoprene coating was carried out by the following method. On one of the contact surfaces, first degreased with benzene, a chlorneoprene prime coat was applied. After drying in air for a period of one hour, liquid neoprene was applied to this surface with an atomizer, after which it was vulcanized at a temperature of 100° for a period of 10 hours. Then a new layer of neoprene was applied to the vulcanized surface by an atomizer, and another vulcanization treatment was performed, etc. It was necessary to apply 5 - 6 layers to obtain a 100-μ-thick neoprene coating.

The molybdenum disulfide lubricant was applied by the following method: ground powdered molybdenum disulfide in an epoxy resin (brand EP074) was introduced in a ratio of 1 part resin to 2 parts MoS_2. With the aid of solvents, the mixture was brought to the required viscosity, after which a layer of lubricant was applied to a previously phosphate-coated contact surface by an atomizer. Then the specimen was thermostated at 200° for one hour to polymerize the layer. A coating thickness of 10 - 15 μ was obtained.

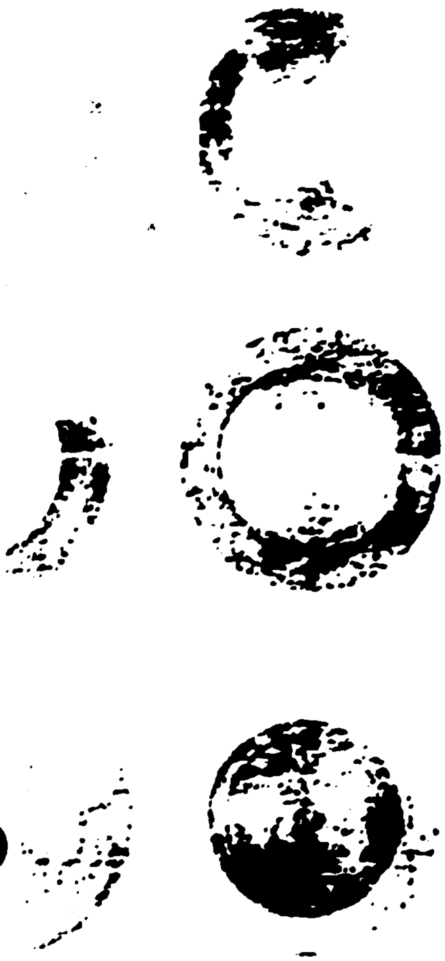
The results of fretting-corrosion tests on these specimens are shown in Figure 1, from which it is seen that under conditions of contact friction for specimens whose contact surfaces were protected by neoprene, fretting-corrosion is not observed after 144,000 cycles of displacement; at the same time, fretting-corrosion appears after only 28,000 cycles of displacement in specimens protected by a molybdenum sulfide-based lubricant.

In the next stage, the protective action of neoprene coatings against fretting-corrosion under conditions of cyclic stress was studied. Fatigue tests were conducted on flat specimens of 1Kh18N9 steel, 0.8 mm thick, unprotected, and coated with neoprene. After a water quench from 1100°, the mechanical properties of 1Kh18N9 steel were as follows: $\sigma_b = 64.5$ kg/mm^2, $\sigma_{0.2} = 34.1$ kg/mm^2, and $\delta = 67\%$.

The method described in [7] was used for establishing contact friction in the stressed section of the specimen.

The results of fatigue tests are shown in Figure 2, from which it is seen that the specimens coated with neoprene and tested under conditions of contact friction possess approximately the same fatigue strength as similar specimens tested under conditions excluding the development of fretting-corrosion, and a significantly higher fatigue strength than uncoated specimens, tested under conditions favorable to fretting-corrosion, as well as under conditions excluding its development. On specimen surfaces uncoated with neoprene, there are brown spots at sites of contact, characteristic of fretting-corrosion;

at the same time, for specimens coated with neoprene and also tested under fretting conditions, at the place of contact with the clamp there were only insignificant traces of friction from the clamp in the coating.



a

b

c

Figure 1. Contact surfaces of 40KhNMA steel specimens after testing under conditions of contact friction under a stress of 200 kg/cm^2 and amplitude 0.05 mm: a — unprotected surfaces, N = 21,600 cycles; b — surfaces protected by MoS_2-base lubricant, N = 28,000 cycles; c — neoprene-protected surfaces, N - 144,000 cycles

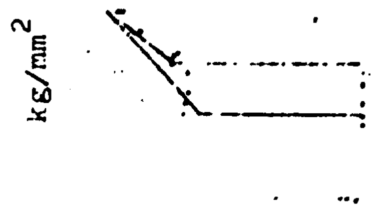


Figure 2. Fatigue curves of 1Kh18N9 steel:

I — for specimens without a coating, tested under conditions excluding development of fretting-corrosion; II — for specimens with neoprene coating; 1 — tested under conditions excluding the development of fretting-corrosion; 2 — under conditions of fretting-corrosion; III — for specimens without a coating, tested under conditions of fretting-corrosion

Thus, tests on laboratory specimens showed good prospects of using neoprene coatings for the protection of coupled surfaces from attack by fretting-corrosion.

In this connection, full-scale stand tests were conducted on a series of parts subjected to industrial damage by fretting-corrosion in the operating process. The use of neoprene coatings to protect coupled surfaces of these parts also gave very favorable results.

Seven parts (nozzle) passed through full-scale tests to failure on the stand. The attachment of the given part to the transition part on the stand and a loading diagram are shown in Figure 3. Two test parts — nozzle — were braced to the transition part by two-sided bolts. The nozzle and transition part were made of 40KhNMA steel, heat treated to a hardness of R_c = 31 - 37, and the coupled surfaces were finished to a smoothness of V 7.

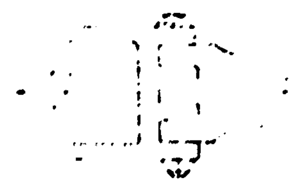


Figure 3. Schematic of bracing and loading on the stand of the nozzle:

1 — transition piece; 2 — joint

Tests were conducted under a static force in the joint equal to 20 t., with simultaneous application of an alternating moment, M = ± 300 kgt, and at a loading frequency of 675 cycles per minute. Fatigue failure of the parts after stand testing occurred in the lugs as a result of severe fretting-corrosion damage to the coupled surfaces. The maximum number of cycles to failure of these parts was $31.5 \cdot 10^6$. The lug of a nozzle damaged by severe fretting-corrosion is shown in Figure 4, and the fatigue fracture of the same lug is shown in Figure 5. Failure of the lug has a fatigue character, the fatigue crack initiating in the section damaged by fretting-corrosion.

Three similar nozzle parts were coated on the surfaces of the lugs with neoprene, 50 - 100 μ in thickness. Tests were conducted similarly to those on the preceding four parts. After working on the stand for more than $45 \cdot 10^6$ cycles, these parts were removed from the test without failure. The development of fretting-corrosion was not observed on the coupled surfaces of these three nozzles.

In addition to the full-scale tests on the nozzles, stand tests were conducted on another part — a vessel made of 18Kh2N4A steel,

Figure 4. Nozzle lug, attacked by severe fretting-corrosion

Figure 5. Fatigue fracture of the lug, attacked by fretting-corrosion. The site of fatigue crack initiation is shown by the arrow

heat treated to a hardness of $R_c = 35 - 41$. Coupled with this was a part made of aluminum alloy AVT1. The finish of the coupled surfaces of the parts was $\nabla 7$. The following two joints were tested: with contacting surfaces protected by neoprene, and without protection by neoprene. In the first case, the vessel worked on the stand for $220 \cdot 10^6$ cycles before failure, and traces of fretting-corrosion on the coupled surfaces of the vessel and the aluminum part were practically absent; at the same time, a similar vessel, except for the neoprene coating, lasted $56 \cdot 10^6$ cycles before failure, and there were regions on the coupled surfaces which had been damaged by severe fretting-corrosion, manifested by site of initiation and growth of fatigue cracks.

Such a favorable effect of the neoprene coatings on the increase of fatigue strength of the parts is explained by the fact that these coatings, which have good adhesion to the metal, are elastic and are not destroyed during operation by the layer between the two coupled surfaces. Therefore, the friction of one metallic surface against another is absent. This prevents the development of physico-chemical processes during contact of two coupled parts.

Thus it has been shown that neoprene coatings safely protect coupled surfaces from attack by fretting corrosion, thereby contributing to the increase in cyclic strength of the parts.

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