UDC 621.891

M.V. Kindrachuk, Sc.D., A.O. Kornienko, Ph.D., S.V. Fedorchuk
(National Aviation University, Ukraine)

Tribological investigations of single and multi-layer composite electrolytic coating

In the work research of dependence of wear resistance single and multi-layer composite electrolytic coating from structure and composition of a matrix-filled type is carried out. Influence of a gradient of properties of multi-layer coating on their wear resistance is considered.

Problem statement. An effective solution to the problem of increasing the wear resistance of parts made from construction materials is the formation on them of wear-resistant gradient layers with a heterogeneous structure of a matrix-filled or a skeleton types. This solution has been successfully realized thanks to using composite electrolytic coatings (CEC), composed of a ductile metallic matrix and wear-resistant powdered filler. In this case, gradient coatings are composite matrix-filled coatings whose regular character is broken in the gradient direction, with the shape, quantity, and dimension of inclusions changing in accordance with a definite law. The present work aims at obtaining data on the wear resistance of matrix-filled single- and multilayered gradient deposits containing SiC inclusions in the Ni matrix and at clarifying the effect of the gradient in the coating depth direction on their wear resistance.

Experiment technique. Composite electrolytic coatings were produced through silting of strengthening SiC powders of various dispersivities with electrolytic nickel. The coatings were deposited on prismatic 10x10x5 mm samples. Deposits containing coarse particles (fractions 100/80, 50/40, and 28/20 μm) were deposited onto the horizontal cathode under impulse stirring of the electrolyte at a current density of 5-10 A/dm^2. The coatings containing more disperse particles (fraction 5/3 μm, SiC_N nanoparticles 50 nm) were obtained on the vertical cathode under continuous stirring of the electrolyte at a current density of 4-5 $A/dm^{2.}$

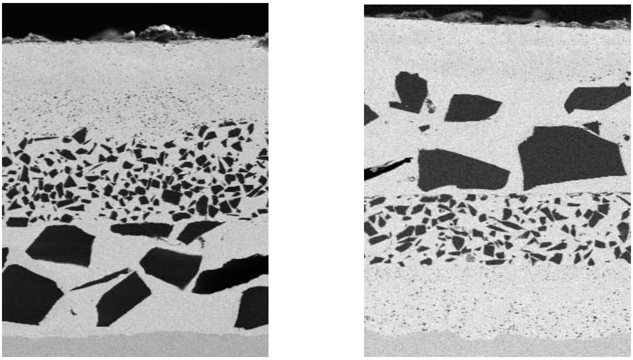
Tests were performed on a M-22M unit under conditions of dry friction. Prismatic 10x10x5 mm samples were studied at a friction speed of 0.5 m/s and a load of 20,40, and 60 N. Steel HRC 45 was as a counterbody, a shaft-plane as a scheme of coupling, the friction path was equal to 1 km. Wear was evaluated from the data on mass loss and the linear wear of the friction couple.

Results of researches.

The coatings obtained were examined using a chemical analysis and wear tests. The contents of inclusions in the Ni matrix were (mass %): SiC_N=2, SiC_5=4, SiC_{28}=12, SiC_{50}=20, and SiC_{100}=24. It was established that the larger particles, the better they are inserted into a coating. By the data, the optimal inclusion content in a coating, from the viewpoint of increase in wear resistance, is 20-30%.

We have developed multilayered gradient coatings the wear resistance of which was higher than that of single-layer coatings for both the direct – fig., *a* (base from Steel 20, layers with inclusions of particles sizing (from base to surface) from

100/80 μm to nanometers) and reverse – fig., *b* (base, fine particles, coarse particles) gradients. The structure of the multilayered coating with a gradient in the depth direction is shown in Fig.



a *b*

Fig. Microstructure of multilayered gradient CEC containing SiC inclusions in Ni matrix, Augmentation ×130: *a* – direct gradient; *b* – reverse gradient

The results of friction and wear tests are shown in Table.

Table

The data of friction and wear tests of CECs with various fillers

Coating type	Load, N	Friction coefficient	Weight wear of sample, mg/km	Weight wear of counterbody, mg/km	Linear wear of friction couple μm/km
1	2	3	4	5	6
Steel 20	20	1,3	75,7	34,6	62
	40	0,91	83,8	24,5	72
	60	0,75	61,5	26,4	56
$Ni+SiC_N$	20	1,3	32,4	5,0	47
	40	0,8	33,9	5,4	48
	60	0,7	36,6	6,8	50
$Ni+SiC_5$	20	1,3	27,7	1,8	42
	40	0,63	34,2	2,5	48
	60	0,69	38,7	8,9	53
$Ni+SiC_{28}$	20	1,1	1,7	5,7	11
	40	0,9	3,4	10,2	22
	60	0,73	9,0	37,4	40
$Ni+SiC_{50}$	20	0,75	1,2	4,5	10
	40	0,62	3,2	9,4	22
	60	0,8	7,7	10,6	25

Table. Continuation

1	2	3	4	5	6
$Ni+SiC_{100}$	20	1,1	69,7	37	49
	40	0,82	93,2	42,5	105
	60	0,66	121,7	54,1	118
Direct gradient	20	1,15	4,0	7,1	40
	40	0,82	10,8	8,7	59
	60	0,75	6,5	17,0	38
Reverse gradient	20	1,3	3,8	13,5	48
	40	0,91	9,3	20,5	65
	60	0,75	6,2	30,0	52

As seen, the coatings obtained by filling of nickel matrix with silicon carbide powder (fractions from 50/40 to 28/20 μm) have the highest wear resistance among single-layered CECs, which is far higher than that of mild Steel 20; the friction coefficient being lower by a factor of 1/3. These data are in good agreement with those obtained before.

Coatings containing smaller and larger particles are characterized by significantly greater wear. For example, under the selected scheme of friction, CECs containing 24 mass % filler with a particle size of 100 μm sharply decreases the capacity for work over the entire load range (20-60 N). However, in the presence of a multilayered CEC with a gradient of quantity and location of inclusions in the layers, the wear resistance increases.

Estimating the total wear (linear and by weight loss), we see that the basic regularities are similar for both small (20 N) and maximal (60 N) loads and the optimal SiC dispersivity is in nickel CEC (50/40 and 28/20). Despite the fact that the content of nanostructured (50 nm) SiC filler is below 2 mass %, the wear resistance of these CECs is not lower than that of Ni-SiC (5/3 μm, 4 mass %) CECs.

Of the greatest interest is the fact that the wear resistance of CECs with both direct and reverse gradients, containing in the upper layer inclusions with dispersivities of 5/3 and 100/80, respectively, is far higher in comparison with that of deposits with no gradient sublayer. It is explained by the fact that such gradient layers have higher dissipative properties than single-layered coatings and more effective disseminate stresses in nickel matrix that is confirmed by the analytical calculations.

Conclusion.

Single-layered composite electrolytic coatings on the basis of nickel have been produced with optimal filler dispersivity from the viewpoint of high wear resistance under selected friction conditions.

The work needs further elaboration. Nevetheless, the conclusion about the positive effect of a gradient sublayer on the wear resistance of coatings can be drawn. The use of such gradient coatings makes it possible to significantly increase the wear resistance of deposits containing fine inclusions (including nanoparticles), which do not have a required wear resistance when used in single-layered coatings.