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Multilayered Composite Solid Lubricating Coating

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Annotation - Peculiarities of receiving of the multilayered composite solid lubricating coating, working at high temperatures and high loads were considered. The technology has been developed and anti-frictional properties of multilayer composite solid lubricating coatings were researched.

Solid lubricating coatings (SLC) are designed to reduce the force of friction and wear in friction centers (1-3). Quite a number of solid lubricant coatings of different chemical nature of binders and particulate matter were developed and researched (1-7). However, it is not so much multilayered SLC, capable of withstanding large enough contact loadings at elevated operating temperature of steel parts.

The multi-layer composite solid lubricating coating (MCSLC), which has high adhesion to the base, good adhesion between the layers and a low coefficient of friction, was developed and investigated. It's allows to raise considerably the wear resistance coatings when working at high temperatures and high loads. The first layer of MCSLC is the compositional nickel-phosphorus coating (CNPC). It was chemically precipitated onto steel samples of next grades C45, 41Cr4, 37Cr4 or 100Cr6 (grades used in Germany). These coatings are the material with the high corrosion resistance and antifriction properties, as well as get a firm coupling with the basis (8-10, 14-20). Use of previously developed modeling techniques CNPC with necessary antifriction properties is allows you to predict the structural and phase states of coatings surface (10-13, 15-24).

For CNPC precipitating by standard method (9, 10) was used the following solution, g/l: $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ - 20-30, $\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$ - 10-15, $\text{CH}_3\text{COONa} \cdot \text{H}_2\text{O}$ - 21-25, $\text{CH}_4\text{N}_2\text{S}$ - 0,002, MoS_2 - 5-6, and pH 4,5-5,5.

A distinctive feature of deposition is the introduction into solution of MoS_2 through 2-3 minutes after the start of the deposition. The time of deposition is from 12 to 60 minutes depending on the steel grade, detail configuration and its further use. The deposition rate is 18 - 35 $\mu\text{m/h}$. All details with precipitated coating were washed by cold running water and conducted the heat treatment at a temperature of 200-210°C during 10-15 min and then cooled

in the open air. To increase the adhesion between the first and third layer was caused a second layer of mix aluminum and chromium containing phosphate binding and thermally treated with 400-410°C within 40-45 min. Then the samples were cooled to room temperature and deposited the third layer - solid lubricating coating (SLC). Layer SLC was deposited from the next multi-component suspensions, g/l: CdCl₂ – 10-30, Zn(NO₃)₂ – 20-50, MgO – 12-36, AgNO₃ – 10-20, H₃PO₄ – 200-280, HNO₃ – 5-20, MoS₂ – 200-250. Depending on the destination of the wares the suspension was inflicted on the second layer by brush, dint of dip or sprayer. After applying the SLC was conducted heat thermal at a temperature of 300°C during 20 to 120 minutes. Compositions of the four suspensions, g/l: suspension 1 - CdCl₂ – 10, Zn(NO₃)₂ – 20, MgO – 12, AgNO₃ – 10, H₃PO₄ – 200, HNO₃ – 5, MoS₂ – 200; suspension 2 - CdCl₂ – 15, Zn(NO₃)₂ – 30, MgO – 24, AgNO₃ – 15, H₃PO₄ – 230, HNO₃ – 10, MoS₂ – 220; suspension 3 - CdCl₂ – 20, Zn(NO₃)₂ – 40, MgO – 30, AgNO₃ – 20, H₃PO₄ – 260, HNO₃ – 15, MoS₂ – 240; suspension 4 - CdCl₂ – 30, Zn(NO₃)₂ – 50, MgO – 36, AgNO₃ – 20, H₃PO₄ – 280, HNO₃ – 20, MoS₂ – 250. Anti-frictional properties tests of the received SLC from four suspensions were conducted by the back-and-forward friction machine developed in FSUE «SDTU «ORION». Tests were conducted on the scheme of ball-plane with moving rate V = 0.04 m/s and load of 1000 MPa at three temperatures: + 23°C, +150°C, + 350°C. At the end of the tests was measured weight wear. Experimental data about antifriction properties of the MCSLC are presented in the table 1.

Table 1

Influence of composition of the suspension on physical-mechanical properties of SLC

Physical-mechanical properties		Number of the composition of suspension			
		1	2	3	4
The thickness of the SLC, μm		20	22	20	18
Friction coefficient	+20 ⁰ C	0,08	0,06	0,07	0,08
	+150 ⁰ C	0,07	0,07	0,07	0,07
	+350 ⁰ C	0,18	0,17	0,16	0,2
Rate of wear, mg/h	+20 ⁰ C	1,9	1,7	2,0	2,0
	+150 ⁰ C	2,8	2,6	3,3	3,5
	+350 ⁰ C	3,8	3,5	4,0	4,5

It is obvious that the received multilayer coatings are the good anti-friction materials in a wide range of temperatures. This is confirmed by tests at the pilot plant FSUE «SDTU «ORION» and at the some industrial enterprises.

Thus, peculiarities of receiving of the multilayered composite solid lubricating coating, working at high temperatures and high loads were considered. The technology has been developed and anti-frictional properties of multilayer composite solid lubricating coatings were researched.

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