Investigation of mechanical properties of CrC-Al2O3-Al composite coating and technological aspects for its production

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Oxide ceramics hard coatings on all types of aluminum and its alloys formed by the recently developed method of the electrochemical micro-arc oxidizing are well known and recognized over the world. This coatings have a number of the improved properties such as no hazardous wastes, ecologically sound, high microhardness and wear resistance at lubricated contact and others. It attracts the increasing commercial concern of many companies and customers [1].

To extend an area of application of this coatings the investigation of its mechanical properties is necessary to realize. Microhardness, porosity, microstructure, adhesion and micro-structure from micro samples were studied and were used to investigate the load rating of the composite such as the Al-Al2O3 and the top-developed Al-Al2O3-CrC.

The base material of the plate sample is the aluminum 2024. The oxide ceramic hard layer Al2O3 is formed with the micro arc oxidizing process. The layer has up to 10 % of pores opened on the inner surface of the sample. The diameter of the pores is up to 4,5 microns. The thickness of the anodic hard alumna is 50…300 microns. The Young's modulus of the Al2O3 layer is 260…270 GPa. The carbide chromium layer was formed on the oxide aluminum layer by the pyrolysis method. The thickness of the CrC layer is 10…50 microns. The Young modulus of the CrC layer is 240…250 GPa.

Micro-structure of the coatings presented at figures was studies with the X-ray analysis on the diffractometer (marked DRON-3M) in CuKα-radiation. The interval of the scattering angles is 2q, which is equal to 20-90o. To prepare the photograph of the coating micro-structure was used the precision method of photography, which include the monochromatization of secondary bundle with the monochromator from pyrolytic graphite and the registration of intensity in the scan mode. The metallographic analysis was made with the microscope on cross-sectional microsections of the samples with the coatings. Microhardness was measured on the device (marked PMT-3). The load on indentor specimen (it is diamond Vickers pyramid) is equal to 0,5 N for 30 seconds. The porosity of micro arc oxide hard coatings was measured by the linear method (the method of secant line).

The tests of the load rating were performed with an automated stand. As indentor were used the steel and the sintered alumna ceramic balls. The diameters of the balls are 3,938 millimeters and 7,938 millimeters. The normal load was varied within the limits from 0,1 N up to 5 kN. To measure the ultimate load results in cracks into the coating the method of acoustic emission was used. As the result of the load rating tests the depth of the hitch made by the indentor was measured with the optic microscope. The hitch depth allows to estimate the deformation level of the composite coating.

The load rating of the composite coatings such as the Al-Al2O3 and the top-developed Al-Al2O3-CrC have been measured and calculated with the ISO standards recommendations. Obtained experimental and calculated data are well correlated one to another. Under contact load up to 1,5 kN the Hertz equations system is accepted the calculations of load rating of the coatings. The calculated values are well correlated to the actual ones. As it seems the rational ratio of thickness of the oxide aluminum layer and carbide chrome layer is about 10 to 1.

To conclude the paper some technological aspects of the coating production are discussed and summarised. A number of presented figures show and explain obtained results.

[1] Jerry L. Patel, Nannaji Saka, Ph.D. A new Coating Process for Aluminum. Microplasmic Corp., Peabody, Mass. www.microplasmic.com

[2] Yoshioka T., Kitahara T., Yuine T. A new method for static load rating of ceramic rolling bearing. – Wear, 1989, 133, № 2, pp. 373-383.