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Investigations of mechanical and tribological properties of nanocomposite Ni-P/Si_3N_4 coating deposited by chemical reduction method on aluminum alloy AW-7075 used on machine parts

SUMMARY

The doctoral dissertation presents the results of examination of mechanical and tribological properties as well as microscopic and profilometric tests of the nanocomposite layers, Ni-P/Si_3N_4, deposited on AW-7075 aluminum alloy. The issue emerged among others from the railway industry, where aluminum alloys are still rarely used for machine parts, despite the significantly lower weight compared to steel. This is mainly due to the low wear resistance of the surface layer. In the dissertation the research has been carried out to define the possibility of increasing: the surface hardness and wear resistance of aluminum alloy parts by using the nanocomposite layer with an appropriate chemical composition. The obtained results from the conducted tests form the basis for modifying the properties of parts made of aluminum alloys by applying the nanocomposite Ni-P/Si_3N_4 layers on their surfaces by chemical reduction. This will increase their durability, reliability, but also will enlarge the scope of their application. The nanocomposite Ni-P/Si_3N_4 surface layers were produced by chemical reduction on aluminum alloy surfaces in a galvanic bath containing: $NiSO_4$, NaH_2PO_2 and ceramic disperse phase Si_3N_4 in presence of $HO(CH_2)_2COOH$. The nanocomposite layers have been made with the use of the ceramic material, Si_3N_4, in the form of a polydisperse powder with the particles size of 20 ÷ 25 nm. The characteristics of the Si_3N_4 phase has been shown by means of transmission electron microscopy. The morphology of the manufactured layers has been examined by means of an optical microscope. The topography of the examined surfaces has been characterised by the contact method with the use of a profile measurement gauge. The influence of the content of the dispersion phase, Si_3N_4, on the mechanical and tribological properties of the layers has been examined. The DSI method (Depth Sensing Indentation) has been applied to determine Vickers micro hardness, Young's modulus and Martens hardness of the layers under examination and their adhesion to the substrate by scratch test. For comparison reasons, Ni-P layers without the built-in dispersion phase have also been examined, as well as the AW-7075 alloy, the substrate of the manufactured layers. The Si_3N_4 particles have been built in the Ni-P layer material in order to increase the hardness, increase in wear resistance of the coating material and to determine the possibility of applying this kind of composite layers for coating products made of the AW-7075 aluminum alloy. The results have shown that the Ni-P/Si_3N_4 layers have higher values of hardness, and Young's modulus, and also better wear resistance in various test conditions, than the Ni-P layers and show good adhesion to the AW-7075 alloy.