Nanostructured surfaces

Physicochemical basis of the light structural alloys surface hardening by ultrasonic impact treatment at cryogenic temperatures

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A considerable attention is attracted to development of untraditional athermic methods of light construction alloys surface work-hardening. The use of ultrasonic impact treatment (UIT) is considered as the effective one. Considerable contribution to development of UIT on air is attributed to the works of E.S. Statnikov, B.M. Mordjuk and G.I. Prokopenko[1]. This method is mainly used for the substantial reducing of remaining stresses in the weld-fabricated connections of casting AMg6 alloy, that assists the increase of their fatigue strength[2,3]. Any possibilities of application UIT in different environments for the achievement of the surface layers high strength states in the deformed precipitation-hardening alloys are a matter of high interest. Not only grains growth during an intensive plastic deformation but also a precipitation or dissolution of secondary dispersive phases affect mechanical properties in such alloys[4].

Regularities in the formation of phase and chemical composition, fine microstructure and mechanical properties of surface layers in D16 aluminum alloy under the UIT in the conditions of quasi-hydrostatic compression of samples in the air, rare gases (argon, helium) and liquid nitrogen ambient were studied in this project.

The following methods were applied: metallography, microdurometry, X-ray analysis, micro X-ray spectrum analysis, TEM and SEM, HEED and tribotechnical tests were done.

A cyclic character of microhardness change in surface layers of D16 alloy depending on oscillation amplitude of tensions concentrator and time of UIT on air and in an inert environment was revealed, which consists in alternation of work-hardening stages, conditioned by structure and phase transformations, as well as plastification stages due to the development of dissipative processes of dynamic recovering and dynamic recrystallization. With the increase of treatment duration under the permanent value of amplitude the effect of work-hardening increases, and recovering takes place up to the permanent value of microhardness, which corresponds to the initial deformation peening and twice exceeds the value of microhardness for the initial state.

The process of oxidization under the UIT on air allows to synthesize a high-strength (up to 12 GPa) oxide layer with a thickness of a few tens of μm simultaneously with nano structuring of superficial layer of D16 alloy. Efficiency of oxidization is determined by duration of treatment. Forming of oxide is conditioned by the processes of mechanochemical interaction of the alloy surface with the atoms of oxygen of environment due to an intensive generation chemically active structural defects.

Work-hardening (in 2,5 time) of D16 alloy surface by means of UIT in an inert environment is conditioned by modification of dislocation structure, deformation forming of nanocrystal structure, and precipitation of nanosize strengthening *S′* phases of Al_2CuMg.

It is shown the unique possibility of work-hardening of D16 alloy surface (in 5 times) by UIT treatment in the liquid nitrogen (77,4 K) ambient, conditioned by synergetic influence of nanostructuring and micro chemical impact processes on aluminum in the process of criodeformation in liquid nitrogen. Cyclic character of changes of micro hardness it is not discovered in this case. The development of dynamic recover processes and the evidences of the dislocation annihilation effect are prevented by deep cooling up to the criotemperatures.

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