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Structural changes and surface layer strengthening of the one-phase, fine-grained Ni_3Al intermetallic compound during incubation period of cavitation.

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Abstract – Cavitation wear resistance, of fine-grained Ni_3Al intermetallic alloy during the incubation period was investigated with the use of stream-impact stand andn results are presented in this paper. Mechanism of formation and destruction of the surface layer under working liquid influence is described. Furthermore, geometrical changes in surface layer are presented as the function of experiment time. It was noticed, that first microcracks are formed on the grain boundaries, especially in the triple contact points. Further surface destruction of analyzed alloy is an effect of strengthening and falling out of critically deformed areas or whole grains. It was stated, that investigated alloy has a supreme resistance for that type of wear in comparison to aluminum alloys, copper alloys and commonly used steels.

Adverse effects on materials have been known in engineering for more then a century. This phenomenon is caused by the changing area of pressures in a liquid, in which bubbles or other closed voids containing gas, vapour or gas-vapour mixture of the given liquid are formed and instantaneously collapse.

Currently, a growing interest is observed again in problems of cavitation damage as new materials and technologies in material engineering have been developed. These may significantly reduce or soften the effects of cavitation. Among materials that may find various applications are alloys based on intermetallic phases, including Ni_3Al intermetallic phases. Ni_3Al-based intermetallic alloys show high strength and specific stiffness, good resistance to corrosion, cavitation, abrasion in various environments, and it has a competitive price of input materials as compared with classic heat-resistant nickel-based alloys [1]. In this respect, alloys based on the Ni_3Al intermetallic phase have one important characteristic: the possibility of obtaining the desired operational properties by a proper choice of alloy components, the conditions of crystallization, and treatment technology that allows the production of material of diverse properties.

On the basis of structural research it was stated that plastic working and heat treatment, conducted as controlled rolling and recrystalisation gives fine grained structure of the analysed alloy with grain size equal $8\pm2\mu m$ (fig. 1).

SEM structural observations made of the cross-sections and the surface threated with the working liquid have shown presence of the strongly plastically strained areas. The microhardness of such areas is twice bigger than in the basis material. After 480 minutes lasting cavitation test the depth of strengthened surfice layer of fine grained alloy ranging 200-250μm is tripled comparing to the same ally with coarse structure in as-cast condition and grain size of 2-3mm.Cavitational wear of the investigated alloy during incubation period is mainly caused by the grain boundary sliding, local strengthening and fatigue crumbling of the critically strengthened parts of grains or whole grains.

Finally it was stated that cavitational wear during incubation period of the analysed fine-grained material is much lower than commonly applied alloys (like brass, bronze, aluminum alloys, steels)

a) b) c)

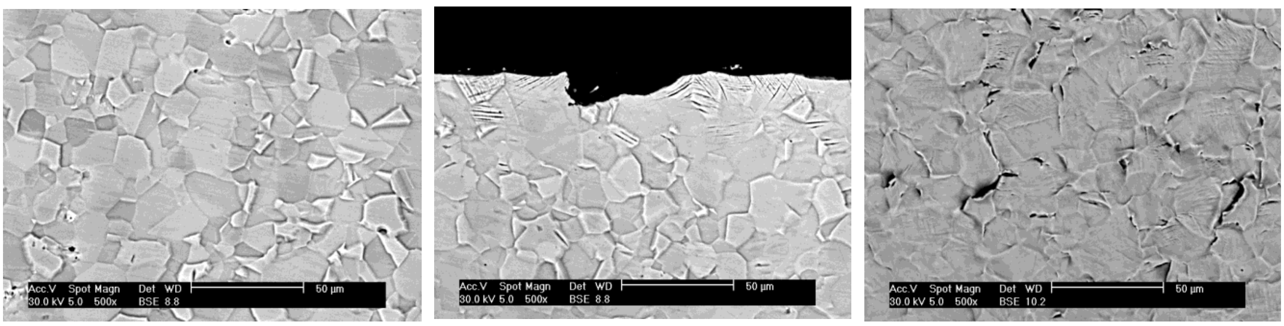

Figure 1: Microstructure of the fine-grained Ni_3Al alloy a) native material, b) cross-sectional view, c) surface view after 480-minutes long to working liquid exposure

References

[1] S.C. Deevi, V.K Sikka, Intermetallics, 4, (1996), p. 357.