АЕРОКОСМІЧНА ТА АВІАЦІЙНА ІНЖЕНЕРІЯ

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EFFECT OF ROLLING TEXTURE ON THE FATIGUE PERFORMANCE OF ALUMINUM REPAIR PATCHES

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Key words: aircraft, damage, aluminum alloys, patches, repair, texture, biaxial loading, corrected Mises criteria.

Introduction. During operation the aircraft fuselage skin is subjected to the influence of many damaging factors. As a result of their action such destructive phenomena as corrosion, fatigue cracks, dents, notches, etc. may occur. One of the commonly used methods of repairing aircraft fuselage skin is the installation of repair patches. However, the practice of using repair patches does not take into account stress-strain state of damaged elements, as well as anisotropy of sheet materials used for repair patches manufacturing [1]. This report represents the results of the researches currently conducted at the Department of Aircraft Design of Kyiv Aviation Institute. The purpose of the research is the improvement of repair procedures by correction of the equivalent stresses calculation methods in the case of complex stress state.

Materials and methods. The main material studied in this work is aluminum alloy 2024T3, which is widely used in aviation industry for modern aircraft fuselage skin.

As a result of plastic deformation which accompanies the rolling process of metal sheets during manufacturing, the metal gets texture, that is, a structure with certain dominant crystallographic orientations. The texture of the metal is determined by the X-ray structural method using so-called pole figures.

The basic calculation method for determination of the equivalent stresses that appears in the aircraft skin is the Mises method.

Results. X-ray structural analysis of aluminum alloy 2024T3 samples represented that the aluminum of the clad layer has mainly the orientation {112}<111>, the core of the samples, i.e. the alloy of the Al-Cu-Mg system has the orientation {110}<112>. The indices {112} and {110} denote crystallographic planes that coincide with the surface of the samples. The indices <111> and <112> denote crystallographic directions that coincide with the longitudinal axis of the samples. The correction of the Mises formula consisted in replacing the load components along the two axes with their projections onto the sliding directions and sliding planes, in accordance with the determined crystallographic rolling texture. The basis for this approach to the calculation of equivalent stresses is the crystallographic nature of plastic deformation and metals fatigue, which occurs by sliding along certain crystallographic slip planes in certain crystallographic directions. Thus, the well-known drawback of the Mises formula is solved – in its traditional form, it does not take into account the anisotropy of real structural materials when calculating equivalent stresses.

For the practical application of the proposed crystallographic approach to improve the repair procedure using repair patches, it is necessary to calculate the stress state in the repair areas. The orientation of the patches of a known texture should provide minimal equivalent stresses determined taking into account the actual crystallographic process of plastic deformation.

Conclusions

Taking into account the crystallographic nature of the metal fatigue process allows us to improve the calculation of equivalent stresses during biaxial loading of aircraft structures and has practical significance, which is achieved by minimizing equivalent stresses in repair patches.

References

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METHODS FOR THE STUDY OF THE INITIAL STAGE OF METAL FATIGUE IN THE CONDITION OF CONTACT WITH SURFACTANTS

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Key words: aircraft, fatigue damage, aluminium alloys, deformation relief, surfactants, Rehbinder's effect.

Introduction. Studies conducted by the Aircraft Design Department of Kyiv Aviation Institute demonstrated that accumulated fatigue damage can be assessed based on the state of the metal surface. This is applicable to materials capable of forming a so-called surface deformation relief, which consists of extrusions, intrusions, and persistent slip bands. It is now proposed to analyze various factors influencing the metal fatigue process by examining the evolution of the deformation relief during cyclic loading.

Materials and methods. Aluminum alloy 2024-T3 was selected for the experiments as it is one of the most widely used materials in the aviation industry. To protect against corrosion, the core alloy is coated with pure aluminum. Due to the high plasticity of pure aluminum, cyclic loading