# EXAMINATION OF NEGATIVE SIDE EFFECTS CAUSED BY THE CORROSION PREVENTIVE COMPOUNDS

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***Анотація***. *В статті представлені вимоги до процедури оцінки негативних побічних ефектів, спричинених застосуванням антикорозійних сполук або інших поверхнево-активних речовин, які застосовуються в авіації. Показано, що негативний вплив на втому конструкцій літака має бути проаналізований на різних стадіях втоми та на різних масштабних рівнях. Розглянуто три аспекти загальної методології: вплив поверхнево-активних речовин на стадії зародження втомних тріщин, відомий як ефект Ребіндера; вплив поверхнево-активних речовин на швидкість розповсюдження втомних тріщин; зменшення втомної довговічності заклепкових з'єднань як результат зменшення сил тертя між листами обшивки. Показано, що всі ці підходи можуть бути об'єднані в одну загальну методологію сертифікації антикорозійних сполук.*

**Introduction.** The use of Corrosion Preventive Compounds (CPCs) reduces the risk of the unexpected failure caused by corrosion damage, but the questions arise about probability of CPCs possible side negative effects on aircraft components' fatigue.

Aircraft fatigue phenomenon currently is analyzed at different scale level and at the different stages of fatigue. Thus the same approaches should be used for the analysis of the side effects of CPCs application.

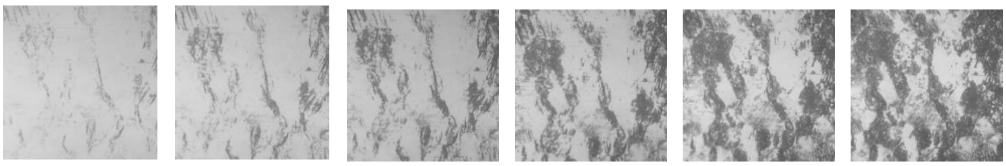
The interaction of CPCs with metal components will be discussed below in terms of: a) CPCs influence on dislocation processes at the initial stage of fatigue (Rebinder effect); b) CPCs influence on crack propagation; c) CPCs influence on the redistribution of forces in aircraft rivets components.

**How to reveal Rebinder effect in the CPCs environment.** Rebinder effect [1] is known as the decrease in mechanical properties which sometimes accompanies the absorption from solution of such surface active agents as the long-chain fatty acids, alcohols and amines. The surface-active agents, lowering the surface energy of the metal, contribute to the emergence of plastic shear.

If the metal fatigue is considered, the Rebinder effect manifests change of correspondent dislocation structure of the surface layer as well as acceleration or deceleration of the damage accumulation process.

At National Aviation University the methodology of fatigue damage assessment based on quantitative analysis of the surface deformation relief has been developed [2]. The methodology relies on the possibility to measure intensity of the deformation relief (damage parameter *D*) by the computer aided light microscopy technique.

The evolution of the relief intensity with the indicated damage parameters *D* presented in the fig.1.



a) b) c) d) e) f)

Fig. 1. Evolution of the deformation relief under fatigue under the $\sigma_{max}$=147 MPa, R=0; 400$^{x}$: a) 15200 cycles, *D*=0,042; b) 30000 cycles, *D*=0,136; c) 47300 cycles, *D*=0,208; d) 100000 cycles, *D*=0,296; e) 258000 cycles, *D*=0,427; f) 711000 cycles, *D*=0,543.

It was proved that the evolution of deformation relief is sensitive to the stress amplitude, stress ratio, sequence of loading, etc. so it can serve as reliable indicator of accumulated fatigue damage for components made of alclad aluminium alloys and for fatigue sensors.

Thus, to reveal influence of the CPCs or any surfactants on initial stage of fatigue the monitoring of the damage relief of the component covered by the CPC should be conducted.

**How to reveal CPC influence on fatigue crack.** Damage tolerance concept in aviation industry assumes the origin and propagation of fatigue cracks. That's why there is strong necessity to know all factors that affect cracks. Analysis of researches in which aviation materials and components, treated by CPCs were tested, proves the probable harmful effect on fatigue crack propagation rate [3].

The test technique used by authors of the paper [3] in our opinion might be improved to make the impact of PCPs more evident and argued.

In our opinion it is more efficient to input CPC on the stable phase of crack growth. To prove this procedure concept the special experiment has been conducted.

The specimens of D16 AT alloy have been tested under the maximum stress 100 MPa and stress ratio R=0. The frequency of loading 11 Hz. The hydraulic machine MUP-20 was used for the loading.

At the first stage of test the specimens without surfactants covering have been tested. No changes of the crack rate are observed.

Let's consider then the results of the examination of the CPC DINITROL AV25 influence on crack propagation (fig.2).

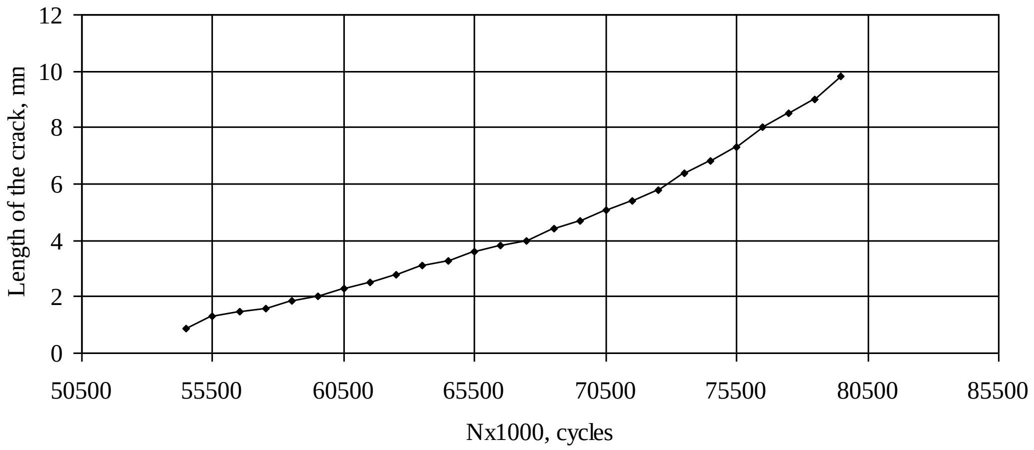



Fig.2. The crack growth before (crack length < 2.0 mm) and after (crack length > 2.0 mm) the covering by DINITROL AV25

The CPC was applied at the process of crack growth, when the crack reached 2 mm length. The number of cycles was 127200 and the rate of growth was correspondent to the stable propagation stage.

As it is seen from the fig.2 the application of DINITROL AV25 has no negative effect in the described conditions of the loading.

This result unfortunately can not be extended to all surfactants. The following test has proved the necessity of examining. The solution of oleic acid, $CH_3(CH_2)_7CH$ in glycerine has been applied as a standard surfactant .

As it is seen in fig. 3, after the covering of the 2.0 mm crack by the glycerine solution of the oleic acid at 120700 cycles of loading, the rate of the crack propagation considerably increases, thus the negative effect is evident.

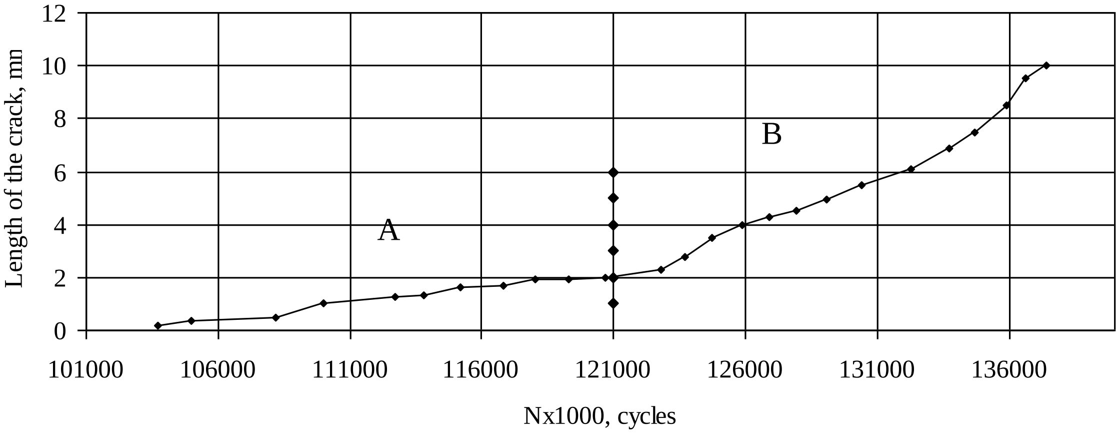



Fig.3. Fatigue crack propagation before (area A) and after (area B) the covering by the oleic solution

Thus, the proposed procedure allows examination of the surfactants' side negative influence on fatigue fracture process and might be used under certification test of CPCs.

**How to reveal CPC influence on the redistribution of forces between riveted components.** Some tests performed in different countries have demonstrated the negative effect of the CPCs on the fatigue of the riveted structural components [4-7].

Some possible mechanisms of the phenomena have been discussed. A major factor in this drop of fatigue life could be the reduction of friction due to the lubricating properties of the compounds. The examining the effect of friction reduction can be performed by special tests simulating rivet joints. The drawing on fig.4 shows how to simulate rivet joint and measure friction between sheets of metal.

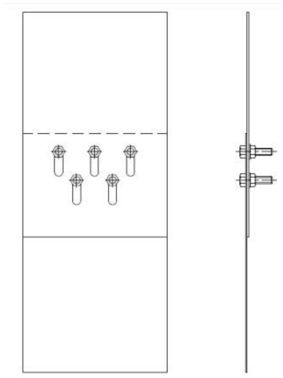


Fig. 4. The simulation of riveted joint to measure friction between sheets of aircraft skin.

The presented specimen simulates two rows lap splice. Instead of circular holes for rivets the openings made so that to provide mutual displacement of the sheets and instead of rivets the bolts are installed. The force of axial drawing-up of bolts is controlled by special calibrated torque wrench spanner so that the axial load corresponds to that produced by the rivet.

The model of the rivet joint is subjected to the slow loading with registration of the force correspondent to the displacement of the sheets from initial mutual position. In fact measured force is a force of friction dependent on the characteristics of CPC penetrated into the crevice between the sheets.

At the first stage of research three series of test have been conducted. In first test the model of rivet joint without treatment was subjected to the loading. In the second test the model was loaded after treatment by DINITROL AV-25, in the third test the model was treated by well known greasing Ciatim-291.

Results presented in the table 1.

Table 1. Results of the friction measurement in riveted joint.

| Treatment | Number of test | | | | | Average value |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| No treatment | 4.93 | 5.11 | 4.57 | 6.76 | 8.24 | 5.922 |
| DINITROL AV 25 | 4.58 | 3.01 | 2.82 | 2.82 | 2.83 | 3.212 |
| Ciatim-201 | 3.91 | 4.63 | 3.52 | 3.83 | 3.80 | 3.938 |

As it is seen from the table the method proposed allows investigation of the friction in the model of rivet joint when the different surfactant penetrate into the gap between the sheets of metals.

As the friction is one of the main factors that influences the redistribution of the forces between the components of joint, by the measurement of friction it is possible to select appropriate covering.

**Conclusions.** The chemical composition of some CPCs allows their classification as surfactants. Interaction of surfactants can lead to the negative side effects both at the stages of crack initiation and propagation. Another harmful factor is the lubricating properties of the CPCs, which together with easy penetration into the crevices can change the friction between the joined components and influence fatigue strength.

For covered by the aluminium layer alloys the influence on initial fatigue stage can be revealed by the analysis of surface deformation relief as an indicator of accumulated fatigue damage.

For the examining of the CPCs influence on crack propagation the CPCs should be used directly under the loading. It allows investigator to ignore fatigue scatter.

To reveal CPCs influence on the fatigue properties of riveted joints instead of numerous fatigue tests the measurements of the forces of friction in the CPCs environments can by conducted.

Altogether these three procedures allow correct preliminary selection of the corrosion preventive compound for aircraft structures.

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