

IMPACT DAMAGES OF COMPOSITE MATERIAL AND STUDY OF THEIR EFFECT ON THE RESIDUAL STRENGTH OF CONSTRUCTIONS

Igor V. Pavelko^{*}, Maxim P. Smolyaninov[†] and Sergey V. Kuznecov[‡]

^{*} Aviation Institute (AI)
Riga Technical University
LV-1019, Lomonosova 1, Riga, Latvia
e-mail: igors.pavelko@rtu.lv, web page: <http://www.ai.rtu.lv>

[†] SIA RSEC "Aviatest LNK"
LV-1073, Rēzeknes 1, Riga, Latvia
e-mail: maksims.smolaninovs@aviatest.lv, web page: <http://www.aviatest.lv>

[‡] Aviation Institute (AI)
Riga Technical University
LV-1019, Lomonosova 1, Riga, Latvia
e-mail: sergei@parks.lv, web page: <http://www.ai.rtu.lv>

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Summary. *A method for determination of upper and lower limits of material strength decrease upon low-speed impact is presented. Experiments on the contact indenting of carbon composite and glass fiber were conducted and analyzed.*

Problem of impact damages of composite materials is one of the main problems of operational strength evaluation of modern airplanes constructions. Therefore, there are two tasks: 1) How to evaluate the impact damage knowing mechanical characteristics of material and impact parameters (weight and speed of the impact object)? 2) How the impact damage influences strength and durability of construction?

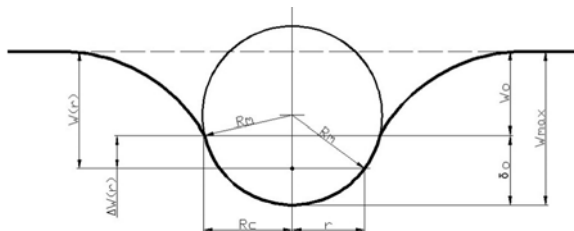


Fig.1. Deformed composite surface after a low-speed impact with an impact object with spherical surface

Authors of the presented work are solving the problem: knowing the maximum material strength, which is determined by independent tests results, it is necessary to determine the impact energy (or force) which corresponds to a particular size of a damage zone, in all points of which a limiting state is reached. The current study deals with a development of this approach. It comprises suggestions and motivated criterions, which allow describing the limits of maximum composite

material strength decrease with known starting mechanical characteristics. One of the proposed criteria is the criterion of an equivalent hole. FE model was created and resolved (Fig.1.) with an ELCUT program for an $t = 2$ mm thick plate of the basis of a pilot study of samples carbon composite KMKY-2M.120.Э.01 with the known elastic constants.

Using the known values of material decomposition strains and FE-calculation results, damaged zone contours were determined for various values of impact energy T . By excluding the damaged zone from the calculation model, for each calculated case were determined: lost area of its cross section; residual area; corresponding decrease in strength. Hole diameter, equivalent to impact with given energy, is equals to lost area to material thickness ratio. This criterion can be used for evaluation of the upper limit of carbon composite strength loss after a low-speed impact.

The criterion of stress concentration can be used for evaluation of a lower limit of strength loss. According to the 3D FE-model of a sample a dent is formed at the impact point which configuration is described by the Fig.1, and size is calculated above as S_{lost} . As a terminal condition some value of the extension stress σ is set, in the current case it is $\sigma = 100$ MPa. It is assumed that the highest stress at the dent border (stress concentration) expands over the whole impaired cross-section. In this case we assume the strength loss coefficient is inversely related to stress concentration factor.

The following complete experiments were conducted. As investigation objects: a) Samples of a glass composite plate made by Fazerverbundwerkstoffe. Fiber orientation 0° - 90° . Fiber volumetric content - 43%; b) Samples of a carbon composite plate made by Fazerverbundwerkstoffe. Fiber orientation $0^{\circ}/90^{\circ}\pm 45$ (quasiisotropic material). Fiber volumetric content - 50%. At the first stage, samples investigation in respect to static stretching was done, in order to determine their mechanical characteristics and to record a stretching diagram. At the second stage a contact loading with cylindrical and spherical stamps was conducted, as well as combined loading with cylindrical stamp. At the third stage, experimental investigations of residual strength for stretching of samples subjected to contact loading, were accomplished. At Fig.2 dependencies of carbon composite and glass fiber strength decrease from the diameter of spherical stamp are demonstrated. They are in a good correlation with previously carried out analytical investigation results concerning determination of upper and lower limits of glass fiber strength decrease upon low-speed impact [1,2] (Fig.3).

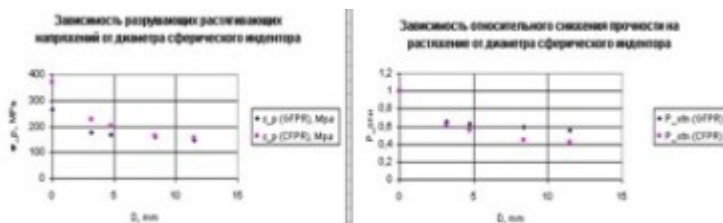


Fig.2. Decrease of composite strength as a result of the impact and contact interaction.

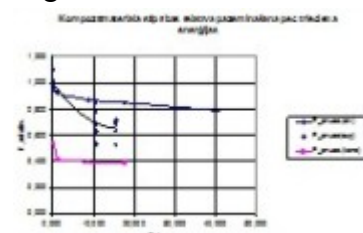


Fig.3. Material KMKY-2M.120.Э.01 strength loss coefficient as a function of the impact energy (from the bottom upwards):

- 1-By criterion of the stress concentrations
- 2-By the experiment results
- 3- By criterion of the equivalent hole

hole

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