

ASSESSMENT OF SPATIALLY-REINFORCED CARBON COMPOSITES EXFOLIATION AFTER A LOW-SPEED IMPACT

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Key words: low-speed impact, carbon-carbon composites, shift strength, impact loading, impact energy, zone of possible exfoliation.

Summary. *A method of evaluation of composite materials damage after a low-speed impact. Mechanical properties of six types of carbon-carbon composite materials have been investigated under compression, lateral bending and shift before and after the impact action. Obtained results were analyzed and the proposed method acceptability was evaluated. FE calculation was performed to determine the interrelation of impact energy and the size of a zone of possible exfoliation and stress intensity.*

One of differential characteristics of carbon-carbon composites is their low crack resistance caused by the carbon matrix fragility. At the same time it's worth to mention that low-speed impacts are the most common in practice. Therefore, the use of carbon-carbon composite materials in construction elements invokes the need to investigate their behavior under influence of the said type of impacts. Main goals of this work are: 1) elaboration of approach to evaluation of damaged composite materials after a low-speed impact, which provides stable and reproducible results at a certain impact loading level; 2) determination of the effect of impact energy on the size of a zone of possible exfoliation and stress intensity.

The essence of the proposed approach is as follows. A square plate of a composite material is tested to determine its twisting strength, and then is exposed to a multiple impact action with

regular strength measurements. Ratio of the determined characteristic after impact action to its initial value allows to indirectly estimate the material sensitivity to damage. Analysis of the obtained experimental data shows that carbon-carbon composites based on a wicker framework are more sensitive to decrease of their shift strength after impact action over the whole material surface, than composites based on transversally stitched material. Contrariwise, under local impact, composite materials of the latter type are more sensitive to decrease of their shift strength. Aligning of fittings stacking angles of carbon-carbon composites does not substantially influence the change of investigated characteristics at low-speed impact. Good agreement of strength relative values at the same impact loading means that the developed method can be used for composite materials damage evaluation.

FE calculation was accomplished to determine the effect of impact energy on the size of a zone of possible exfoliation and stress intensity. At first we have determined an interrelation between the impact energy and resultant contact strains (contact force). Calculation was

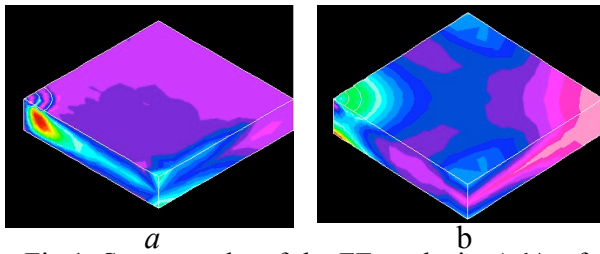


Fig.1. Some results of the FE analysis. A $\frac{1}{4}$ of a plate, jammed along the perimeter, is shown.

performed by a method of successive approximations with gradual increase of a contact force. At the second calculation stage we have determined a size of the zone of possible exfoliation and strained condition, caused by a contact force P_k which corresponds to the predetermined impact energy. Some results of a strained-deformed condition calculation are presented. At the Fig.1a a distribution of tangential strains in the plane of a plate

through its thickness is demonstrated, which are a main reason for interlayer decomposition of a composite material. It can be seen that the maximum strains of interlayer shift appear approximately in the middle plane of a plate and are of a significant value. Comparison of these strains with independently determined interlayer strength of a composite help to assume that at the given impact energy these strains can cause exfoliation in substantially extended zone. Shift strength of a plate with calculated exfoliation is assumed to be compared with experimental results. After the impact which causes a dynamic bend of a plate, other types of local composite material damage are possible (flaking of a contact zone, fiber disruption, etc.) In particular, Fig. 1b demonstrates FE calculation results of equivalent strains according to Mises-Hill theory. It can be seen that their maximum amount and possible local destruction are concentrated at the opposite plate surface around the impact epicenter.