MICROMECHANICAL APPROACH TO STRENGTH AND FRACTURE ANALYSIS OF HETEROGENEOUS MATERIALS

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Annotation. The article outlines the main regularities of the macromechanical approach to the analysis of the destruction of heterogeneous materials, it is also shown that the predictive capabilities of the various proposed theories of the destruction of composite materials.

Keyword. Strength, fracture heterogeneous material, composite, reinforced, particles, composite, fiber, matrix, fiber, interface, volume fraction

Ensuring the strength of structures is carried out as follows. At the stage of their design, a calculated or experimental assessment is made of the possibility of the development of various types of destruction processes in the load-bearing elements of the designed structures: fatigue, brittle, quasi-static, destruction due to creep of the material, corrosion, wear during operation, etc. At the same time, all possible structures, currently known mechanisms of destruction of the material, should be considered., from which its supporting elements are made. For the newly created composite material, these destruction mechanisms are identified at the stage of the research cycle of design. A certain strength criterion is associated with each of these destruction mechanisms — one or another characteristic of the physical state of the material of the composite material elements, determined by calculation or experimentally. For each of the structural material strength criteria, its limit values are experimentally established. According to the limit values, the permissible values of these criteria are further determined. The latter are determined, as a rule, by dividing the limit values of the strength criterion by the corresponding safety factor. The values of the safety margin coefficients are assigned based on operational experience, taking into account the degree of responsibility of the designed structure, the estimated life of its operation and the possible consequences of its destruction.

In heterogeneous materials, fracture is a multiscale complex phenomenon resulting from the interaction of various contributing factors, such as matrix properties, fibers, matrix-fiber interface, fiber volume fraction and load. conditions [1]. There are also numerous types of destruction of heterogeneous materials, including fiber destruction under tensile load, microstability (bending) and shear due to compressive load, matrix cracking, plastic destruction of the matrix (without cracking), interfacial detachment, delamination and others [2]. It is extremely difficult to fix all these types of destruction using any given criterion of destruction under various load conditions. Thus, it is very important to pay due attention to local fields, which play a vital role in the occurrence and progression of material destruction. The destruction of heterogeneous materials is usually modeled using both macromechanical and micromechanical approaches. Now studying scientific heritage, socio-political activities and acquaintance youth charity of our above-stated ancestors is considered one of the main urgent objectives of the modern intellectuals.

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In the macromechanical approach [3], the fracture analysis is performed on the basis of averaged general properties of heterogeneous materials. This approach does not take into account local field disturbances in each component of heterogeneous materials. This could potentially affect the strength prediction of heterogeneous materials. Numerous researchers have proposed various approaches to fracture analysis to study the initial and final destruction of a composite reinforced with continuous fiber. More than 19 rejection criteria were analyzed in [2,3,4,5]. It is noticed that all authors used different assumptions and criteria for fiber and matrix. Most of them used the isotropic properties of the composite to predict the destruction of composite materials. However, in some cases, the destruction is analyzed by a fictitious assumption that both the fiber and the matrix are in an isotropic medium. Accordingly, the criteria for the destruction of the fiber and matrix are used depending on the load conditions. Most approaches have used classical theory to reconstruct strain stress fields to analyze the fracture of composite materials, but classical theory may not be rigorous enough to cover all fields, in particular transverse shear and normal stress, which play a role. A significant role in the delamination of composite materials [6,7]. In many of these approaches, both linear and nonlinear analysis has been proposed to analyze the initial and final destruction of materials. Some of the models predicted the final destruction without analyzing the progressive damage of the material, while others assumed models with constant or exponential degradation of stiffness[8].

It is also shown that the prognostic capabilities of the various proposed fracture theories do not allow us to accurately and consistently assess the tensile strength of fiber-reinforced composites for various loading conditions, as indicated in the reference materials[9, 10]. The main reason for the contradictory forecasts of the proposed approaches to the destruction analysis may be due to the lack of use of accurate local fields that significantly affect the destruction of the composite. The assumptions made when formulating approaches to destruction also contribute to the inefficient analysis of the destruction of composite materials[11].

Moreover, all the proposed approaches to fracture analysis used for composites reinforced with continuous fiber are not applicable for other types of heterogeneous materials, such as particle-reinforced composites, discontinuous fiber reinforced composites, and woven composites[12]. This is due to the fact that assumptions have been made about applying the criteria only to composites reinforced with continuous fiber, although the forecasts are still not good enough[13]. If approaches to destruction are developed on the basis of components of heterogeneous material, especially at the material point, models can be reasonably used for other types of heterogeneous materials.

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