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MESOMECHANICAL ANALYSIS OF A COMPOSITE CONSIDERING INTERNAL CONTACT INTERACTION

Volha Yakubovich, Alexandr Shimanovsky(*)
Department of Technical Physics and Engineering Mechanics, Belarusian State University of Transport, Gomel, Belarus
(*)*E-mail: tm.belsut@gmail.com*

ABSTRACT

It was performed a finite element modeling of stress-strain state of the composite, reinforced by grains. A periodicity cell consisting of parts of two grains and the surrounding matrix was taken as a model. It was taken into consideration the contact interaction between grains and a composite matrix. It was demonstrated that a decrease in the diameter of the reinforcing grains leads to significant improvement of grains-matrix adhesion and an increase in the composite strength.

Keywords: computer modeling, reinforcement by grains, stress-strain state, contact interaction, adhesion.

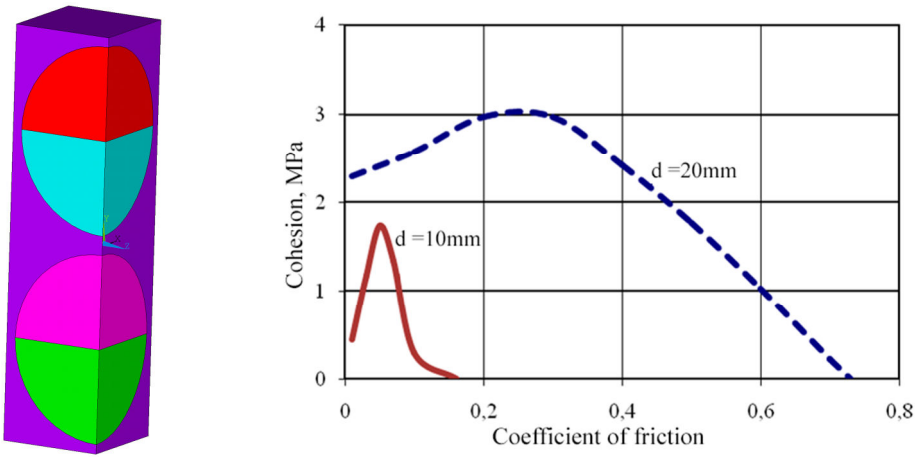
INTRODUCTION

Nowadays composites reinforced by grains are used in various fields of technics. However, the theoretical analysis of their stress-strain state is complicated because of the need to analyze mechanical systems with a complex configuration and taking into account the characteristics of the composite material phases' properties. Investigations in this area are based on two main strategies. The first one supposes to fulfill the analysis of the average stress and strain fields for each construction component (Mei, 2010), but it doesn't allow to determine the characteristics of the stress-strain state depending on the material heterogeneity. The second approach is to examine the models of a representative model of a volume with rigidly connected material phases (Mishnaevsky, 2001). This volume usually has a form of periodically repeating cells.

We suggested a new model of a composite material reinforced by grains (Shimanovsky, 2013). Its feature is the fact of taking into account the reinforcing filler-matrix contact interaction. It corresponds to the structure of composite material as a filler with a transit zone located around homogeneous matrix (Barness, 1978). The presented paper demonstrates an investigation based on the above mentioned model directed to analyze the influence of the grain size and adhesion characteristics between composite material phases on the material stress-strain state. Computations are performed using ANSYS finite element analysis engineering program software. As a model it was taken a periodicity cell consisting of two grains' parts and a surrounding matrix. For the computations there were used the following model parameters: filler and matrix elasticity modulus - 50 and 30 GPa, Poisson's ratio - 0,15 and 0,27 correspondingly. Friction coefficient and adhesion values for the contacting areas of matrix and grains varied in a sufficiently wide range. The loading of the periodicity cell upper face was ensured by uniformly distributed pressure of 30 MPa. On the other faces a symmetry condition was imposed.

RESULTS AND CONCLUSIONS

As a result of the simulation there were obtained the schemes of stresses and deformations distribution in the periodicity cell volume. The performed computations showed that at low values of friction coefficients and adhesion it can appear the relative displacement of the grain and matrix surfaces during the time period from the load application moment till the system returns to equilibrium state. Fig. 1 demonstrates the dependence of the maximal cohesion with possible slip on the friction coefficient. The integrity of the material under applied load is provided only for the points located above the curves shown in Fig 1, b. If the cohesion is insufficient, the material begins to flake. This fact indicates that the presence of material strength lack under the action of 30 MPa compressing pressures. Fig. 1 also shows that reducing the size of the reinforcing grains from 20 to 10 mm leads to a considerable reduction of cohesion required to ensure the integrity of the material.



(a) (b)

Fig. 1 - Geometry model and computational results: a) the periodicity cell, б) the friction coefficient-cohesion dependence for the case of the required composite strength ensuring

The required adhesion values for the ensured strength of composite material constructions can be determined carrying out similar computations for other sizes of reinforcing elements. These values should be a determining parameter in the process of a rational connecting element selection.

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