# Finite Element Modeling of Effective Properties of Nanoporous Thermoelastic Composites with Surface Effects

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## ABSTRACT

This investigation concerns to the determination of the material properties of nanoscale thermoelastic composites of an arbitrary anisotropy class with stochastically distributed porosity. In order to take into account nanoscale level at the borders between material and pores, the GurtinMurdoch model of surface stresses and the highly conducting model are used. Finite element package ANSYS was used to simulate representative volume and to calculate the effective material properties. This approach is based on the theory of effective moduli of composite mechanics, modeling of representative volumes and the finite element method. Here, the contact boundaries between material and pores were covered by the surface membrane elastic and thermal shell elements in order to take the surface effects into account.

For automated coating of internal boundaries of pores in the cubic representative volume the following algorithm was used. At the beginning, as a result of the formation of the porous structure, the finite element mesh from octanodal cubic elements was created, some of which had the material properties of thermoelastic material, and the other part of the elements had the material properties of the pores (with negligible elastic stiffness moduli). Further, only the finite elements with thermoelastic material properties were selected. The resulting elements on the outer boundaries were covered by four nodal target contact elements. Then, the contact elements, which were located on the external surfaces of the full representative volume, were removed, and the remaining contact elements were replaced by the four nodal membrane elastic elements. As a result, all the facets of the contact of thermoelastic structural elements with pores were coated by membrane finite elements.

The next step consisted in solving the static problems for obtained representative volume with the main boundary conditions which were conventional for effective moduli method. Further, in the ANSYS postprocessor the averaged stresses were calculated, both on the volume finite elements and on the surface finite elements. Finally, the effective moduli of porous composite with surface effects were calculated from the corresponding formulas of the effective moduli method by using the estimated average characteristics.

In the results of computational experiments, the following features were observed. If we compare two similar bodies, one of which has usual dimensions and the other is a nanoscale body, then for the nanosized body due to the surface stresses the effective stiffness will be greater than for the body with usual sizes. Furthermore, for the porous body of the usual size the effective elastic stiffness decreases with increasing porosity. Meanwhile, the effective stiffness of nanocomposite porous body with the same porosity may either decrease or increase depending on the values of surface moduli, dimensions and number of pores. This effect is explained by the fact that the sizes of the surface pore with surface stresses depend not only on the overall porosity, but also on the configuration, size and number of pores. We can observe similar effects for the effective thermal conductivity coefficients.

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