Micromechanical Modelling of Composite and Smart Materials and Structures

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Abstract

The mathematically rigorous micromechanical modeling of composite materials and thin-walled composite reinforced structures built of multiple small-size unit cells is based on the multi-scale asymptotic homogenization method. Indeed, the proof of the possibility of homogenizing the composite material of a regular structure, i.e., of examining an anisotropic homogeneous material instead of the original highly inhomogeneous composite material, is one of the principal results of this theory. Asymptotic homogenization method has also indicated a method of transition to a problem for a homogeneous material described by a set of the effective properties. This transition is accomplished through the solution of the so-called local problems formulated on the unit cell of the composite material. The solution of these unit cell local problems allows determining the effective properties and distribution of local fields, e.g., displacements and stresses. The theoretical background of this approach will be introduced, and author's results in the developing the micromechanical models and their application to the analysis of practically important composite structures, including grid-reinforced composites, wafer-reinforced, lattice and sandwich composite shells will be presented. In particular, one of considered examples represents micromechanical modelling of the carbon nanotubes. See [1-5] for details.

Next, the smart composite materials will be addressed. Smart structures integrate sensors and actuators. They have the ability to respond adaptively to changes in environmental conditions, and therefore significantly increase their functionality and serviceability. Major types of smart structures will be discussed, and the general theory of smart materials will be introduced, see [6] for details.

References

[1] A.L. Kalamkarov (2014) Asymptotic Homogenization Method and Micromechanical Models for Composite Materials and Thin-Walled Composite Structures, Chapter 1 in "Mathematical Methods and Models in Composites," pp. 1-60, Imperial College Press: London, UK.

[2] A.L. Kalamkarov and A.G. Kolpakov (1997) Analysis, Design and Optimization of Composite Structures, Wiley: New-York.

[3] A.L. Kalamkarov (1992) Composite and Reinforced Elements of Construction, Wiley: New-York.

[4] A.L. Kalamkarov, I. Andrianov, V. Danishevs'kyy (2009) Asymptotic Homogenization of Composite Materials and Structures, Trans. ASME, Applied Mechanics Reviews, Vol. 62, Issue 3, pp. 030802-1 – 030802-20.

[5] A.L. Kalamkarov, A. Georgiades, S. Rokkam, V. Veedu and M. Ghasemi-Nejhad (2006) Analytical and numerical techniques to predict carbon nanotubes properties, International Journal of Solids & Structures, Vol. 43, Issues 22 - 23, pp. 6832-6854.

[6] A.L. Kalamkarov and A. Drozdov (1997) Optimal Design of Intelligent Composite Structures, Journal of Intelligent Material Systems & Structures. Vol. 8, No.9, pp. 757–766.