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Lidiia Nazarenko, Henryk Stolarski, Holm Altenbach

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Thermo-elastic Properties of Random Particulate Nano-materials for Various Models of Interphase

Lidiia Nazarenko[a*], Henryk Stolarski[b], Holm Altenbach[a]

[a]Institute of Mechanics, Otto von Guericke University Magdeburg, Universitätsplatz 2, 39016 Magdeburg, Germany

[b]Department of Civil, Environmental and Geo- Engineering, University of Minnesota, 500 Pillsbury Drive S.E., Minneapolis, MN 55455, USA

[*]Corresponding author. Tel.: +49(0) 3916751843, fax.: +49(0) 3916712863. lidiia.nazarenko@ovgu.de

Abstract

A mathematical model based on the method of conditional moments combined with a notion of the energy-equivalent inhomogeneity is adopted here in the investigation of the effective thermo-elastic properties of random nanomaterials. In the proposed model the inhomogeneities and their interphases with the matrix are replaced by energy-equivalent inhomogeneities with mechanical and thermal properties modified so as to incorporate the interphase effects. The effective coefficient of thermal expansion is subsequently determined by the method of conditional moments. Closed-form expression for the effective coefficient of thermal expansion of a composite consisting of a matrix and randomly distributed spherical inhomogeneities is derived for the Gurtin-Murdoch and spring layer model of interphases. Two numerical examples are presented to illustrate the quality of the approach.

Keywords: spherical nano-particles, composites of stochastic structure, effective coefficient of thermal expansion, size dependence

1. Introduction

Determination of the effective properties of even the most complex composite is conceptually rather straightforward: it requires a solution of a suitably chosen (heterogeneous) representative volume element (RVE) followed by proper averaging of the fields involved (displacements, strains, stresses in thermo-mechanical analysis). The difficult (or at least absorbing) part of the process is its solution phase which has to consider RVE with large number of inhomogeneities. The level of those difficulties is particularly high when the shape of the inhomogeneities is not simple, when their distribution is random, and /or when there is a need to consider inhomogeneity/matrix interphases. One (brut-force) approach to handle those more complex situations consists of employing various numerical methods [1, 2, 3]. The advantage of such an approach is that only through numerical solution various, often important,