# Evolution of tolerance averaging technique on the example of thermo-elasticity problem in micro-heterogeneous structures

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## Abstract

The main aim of this contribution is to formulate mathematical model of linear thermo-elasticity in multicomponent structures. Considered composites, in micro level, have quite well organized layout of components, providing space varying effective material properties of overall elastic conductor in one of main directions. Therefore, we deal here with a special case of functionally graded materials, cf. [2]. The heat transfer equation, in a conductor under consideration, is based on the Fourier's law, and the equations of motion – on the Newton's and Duhamel-Neumann's law. All that equations, in discrete description, have highly oscillating and discontinuous coefficients, which may cause many numeric problems in solvability. In order to derive the averaged model equations of thermo-elasticity with continuous coefficients, taking into account the microstructure size too, the tolerance averaging technique was applied. This technique is based on the concept of tolerance and indiscernibility relations and on the definition of slowly varying, tolerance periodic and highly oscillating functions. The general modelling procedures of this technique are given in [2, 4-6], and its application to the simplest problems of thermo-elasticity can be found in [1-2]. The definitions related to tolerance averaging technique, together with the averaging operator, evolved or changed through the years. Thus, this consideration concerns few variations of this technique in order to compare each other. Numerical results for all these approaches, along with finite element method, are given and presented on basic examples.

Keywords: **Thermo-elasticity, Composite, FGM, Tolerance averaging technique**

### References

[1] Ostrowski P. (2014), Thermoelasticity in a two-phase hollow cylinder with longitudinally graded material properties, *Shell Structures. Theory and Applications Vol.* 3, Taylor & Francis Group, London, 133-136.

[2] Ostrowski P. (2017) Tolerance Modelling of Thermomechanics in Microstructured Media, Monographs of Lodz University of Technology, Łódź.

[3] Suresh S., Mortensen A. (1998) Fundamentals of Functionally Graded Materials, The University Press, Cambridge.

[4] Woźniak Cz., Wierzbicki E. (2000) Averaging Techniques in Thermomechanics of Composite Solids, Wydawnictwo Politechniki Częstochowskiej, Częstochowa.

[5] Woźniak Cz., Michalak B., Jędrysiak J. [ed.] (2008) Thermomechanics of Microheterogeneous Solids and Structures, Monographs of Lodz University of Technology, Łódź.

[6] Woźniak Cz. et al. [ed.] (2010) Mathematical Modelling and Analysis in Continuum Mechanics of Microstructured Media, Silesian Technical University Press, Gliwice.