Macroscopic Dynamics of Materials with Microstructure

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ABSTRACT

Modern advanced materials (composites, FGM, SMA, ...) are inhomogeneous by definition. Their properties depend on composition (microstructure). The composition may be rather simple or extremely complex depending on the fabrication of the materials. Material with microstructure needs a constitutive model for the description of the microstructure influence on overall material behaviour. Microstructure is usually characterized by a length scale which is smaller than the length scale of the element. Nevertheless, influence of microstructure may not be necessary small, especially in dynamics.

There are different possibilities to describe the microstructure influence. If microstructure can be prescribed (like in laminates), the solution can be obtained by using rather simple governing equations for constituents. The medium in this case is inhomogeneous and may be sufficiently complex. In another limiting case, where existing microstructure is too random, homogenization methods lead to a rather simple "effective" medium, but the governing equations become much more complex in order to take into account the microstructure influence. An intermediate approach is the introduction of internal variables, which reflect the influence of microstructure at the macroscopic level of description.

Generalized one-dimensional wave equation with size effect [1] is represented in the framework of the internal variable theory. This equation is rewritten in the form of conservation laws and compatibility conditions (system of equations of first order) both for micro- and macromotions. Due to the coupling of these systems of equations, a non-zero solution exists even for zero initial and boundary conditions for internal variables. Numerical solution is obtained by finite-volume wave-propagation algorithm with source terms. Results of numerical simulations of wave propagation in the medium with microstructure are compared with similar results for a periodically layered medium.

REFERENCES

[1] J. Engelbrecht, A. Berezovski, F. Pastrone, M. Braun. Waves in microstructured materials and dispersion. *Phil. Mag.*, **85**, 4127–4141, 2005.