FE^2 FULLY COUPLED THERMOMECHANICAL ANALYSIS OF COMPOSITE MATERIALS WITH NONLINEAR BEHAVIOR

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Abstract

The current work deals with FE^2 periodic homogenization analysis of composite media undergoing fully coupled thermomechanical loading conditions. Following the framework presented in [1], the material constituents are considered to obey the generalized standard materials laws and the characteristic equations of the problem (balance laws, thermodynamic principles) are expressed and satisfied in both microscopic and macroscopic scales.

In the numerical strategy followed here, the coupled thermomechanical problem of a nonlinear dissipative composite is solved through a simultaneous analysis in both scales, by adopting the principles of the FE^2 methodology [2], extended to thermomechanical problems. A unit cell is assigned at every macroscopic point of the structure and the numerical calculations are performed through a "return mapping algorithm" scheme: Each unit cell problem is solved for given macroscopic strain and temperature increments (provided by the macroscopic analysis) and it computes a) the macroscopic stress, as well as the microscopic strains, stresses and internal variables and b) the macroscopic thermomechanical tangent moduli. This information is then transfered to the structure, investigating if the macroscopic balance equations are satisfied [3].

For the numerical computations in both scales the finite element commercial software ABAQUS is utilized. A specially designed Meta-UMAT subroutine allows the connection between the macroscopic structure and the microscopic unit cells attached to every macroscopic Gauss point. The analysis is fully three dimensional and a parallelization procedure is adopted for facilitating the analysis and reducing the computational time. The numerical examples presented here illustrate the numerical strategy capabilities and the potential applications.

References

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