Palestra Internacional

Prof. Adnan Ibrahimbegovic (h=48), UTC/Sorbonne Universités

Quinta-feira, 12 de março de 2020, às 10:30

Sala S-07, Prédio da Engenharia Civil

Refined modelling of smart structures: coupled thermomechanical-electromagnetic formulation and FE computations

Refined modelling of smart structures: coupled thermomechanical-electromagnetic formulation and FE computations

Adnan IBRAHIMBEGOVIC*, Pablo Moreno-Navarro*, Ivan Rukavina*,
Alejandro Ospina*, Faker Ben Belgacem*, Jose-Luis Perez-Aparicio+

* Université de Technologie Compiègne – Sorbonne Universités, France

+ Polythecnic University of Valencia, Spain

Abstract

Consistent thermodynamics framework is presented, capable of coupling elastic, thermal and electric fields. The complete set of governing equations is obtained from the conservation principles for electric charge, energy and momentum. The second principle of thermodynamics is considered to introduce the irreversible phenomena, such as plastic dissipation or Joule's heating. The constitutive relations are derived from the Helmholtz free-energy potential for each corresponding dual variable in terms of the defined set of state variables.

The first solution procedure is entirely based the finite element method and time-stepping schemes. We can ensure fast convergence properties of the finite element computations with the proposed coupled elasticity and plasticity models [1, 2]. The implementation is carried out in a research version of the well-known computer code FEAP [5]. Several numerical simulations are presented in order to illustrate the proposed model and formulation capabilities or providing an enhanced formulation of an important practical application in terms of Peltier cells.

The second solution procedure is also examined with an alternative coupling, where we bring into seamless coupling two existing codes: solid mechanics FEAP [3] and electromagnetics GetDP [4], which requires the mortar elements in order to ensure the seamless communication between different fields [5, 7]. The challenge to ensure the unconditional stability for the operator split computations, is achieved by following in the footsteps of our works coupling FEAP with Open-Foam code for fluids [6]

References

[1] P. Moreno-Navarro, A. Ibrahimbegovic, J.L. Perez-Aparicio, Plasticity Coupled with Thermo-Electric Fields: Thermodynamics Framework and Finite Element Method Computations, Computer Methods Appl. Mech. Eng., Vol. 10, pp. 543−561, (2017).
[2] P. Moreno-Navarro, A. Ibrahimbegovic, J.L. Perez-Aparicio, Linear behavior for fully coupled thermo-electro-magneto-mechanic systems, Coupled Systems Mech., 8, 5-26, (2018).
[3] Zienkiewicz O.C., R.L. Taylor, The Finite Element Methods, vols I, II, III, Elsevier, (2005).
[4] P. Dular and C. Geuzaine. GetDP: a general environment for the treatment of discrete problems. http://www.geuz.org/getdp/ , (2015).
[5] F. Ben Belgacem, A. Buffa, Y. Madey, The mortar finite elements for 3D Maxwell equations: first results, SIAM J. Numer. Analysis, 39, 880-901, (2001)
[6] A. Ibrahimbegovic, R. Niekamp, C. Kassiotis, D. Markovic, H. Matthies, Code-coupling strategy for efficient development of computer software in multiscale and multiphysics nonlinear evolution problems in computational mechanics, Advances in Engineering Software, 72, 8-17, (2014)
[7] P. Moreno-Navaro, A. Ibrahimbegovic, A. Ospina, Multi-field variational formulations and mixed finite element approximations for electrostatics and magnetostatics, Computational Mechanics, 65, 41-59, (2020)