LMS Seminar

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Numerical homogenization and model reduction for transient diffusion and coupled mechanics problems

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ABSTRACT

Homogenization of transient diffusion problems requires to first analyze the ratios between the characteristic diffusion times of each constituent the material consists of, and the loading characteristic time in order to determine if the microscale and the macroscale can be separated or not. For some materials under particular loading conditions, a full separation of scales is not achieved. Hence, computational transient homogenization techniques should be performed to account for microscale transient effects. However, since the microscopic problem has to be solved at each macroscopic material point in time, the homogenization in transient regimes comes with a substantially higher computational cost with respect to those required in quasi-static regime.

This talk will present computationally efficient numerical homogenization techniques for transient diffusion phenomena coupled mechanics in heterogeneous materials. The content of this talk is mainly extracted from the PhD work of Abdullah Waseem [4, 2, 3, 1]. For linear problems, and considering a regime of relaxed separation of scales, Conventional Transient Homogenization is replaced by a Reduced Homogenization based on a mode selection, following a Craig-Bampton mode synthesis, which allows to make emerge an enriched-continuum formulation with few internal variables. Then a two-stage solution procedure is followed: (i) an offline stage in which discrete quantities associated with the microscale problem are pre-computed, (ii) an online stage where enrichment variables are solved for, from which macroscopic quantities can be obtained at a low price and used to compute the mass diffusion at the macroscale. However, such approach is no longer valid for non-linear responses. But an approach using data sets of averaged responses generated by numerical simulations carried out on an elementary cell with the above reduced model could be successfully implemented. Especially, such approach clearly showed the emergence at the macroscale of non-Fickian behaviour from linear ones of individual microscale constituents.

BIOGRAPHY

Thomas Heuzé is Assistant Professor at Centrale Nantes, and is affiliated to the Institut de recherche et génie civil et mécanique (GeM). His research activities deal with coupled thermo-mechanical phenomena in metallic structures. These activities are focused on their modeling, the development of numerical methods and strategies to solve these models, and on engineering applications in which such coupling appear and require the development of advanced models and numerical techniques. Original numerical schemes as well as variational constitutive update were developed to this end. Applications are related with high pulsed power technologies developed at GeM, especially magnetic pulse welding/forming or disassembling, or electrohydraulic forming/crimping.

Thomas Heuzé is also head of the junior section of the french association of computational mechanics CSMA since 2019, and member of it since its foundation in 2017. He is also member of the ECCOMAS Young Invertigator Committee (YIC) since 2019.

REFERENCES

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[4] Waseem, A., Heuzé, T., Stainier, L., Geers, M.G.D., Kouznetsova, V.G., 2020b. Model reduction in computational homogenization for transient heat conduction. Computational Mechanics 65, 249–266.