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ON THE OBJECTIVITY OF THE MULTISCALE RESPONSE IN TRANSIENT THERMAL CONDUCTION PROBLEMS

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Abstract. The multiscale modeling has been consolidated as a fundamental tool for the study of heterogeneous materials and multiphysics phenomena in engineering. In particular, the computational homogenization technique based on the Representative Volume Element (RVE) has proven to be effective in the description of systems with complex behavior. However, the extension of these methods to transient thermal problems has revealed significant challenges, especially with the appearance of a thermal inertia or second order term that introduce an undesirable dependence on the size of the micro-scale, compromising the objectivity of the macroscopic response. Several investigations have addressed this problem in the context of transient heat conduction and thermomechanical problems. In most cases they highlight the importance of preserving the second-order term that emerges from the first-order computational homogenization process when dealing with these transient phenomena, by capturing the dynamic effects associated with the micro-structure. In this sense, the present work seeks to provide a better understanding of this term, showing in a clear and simple way which is the specific component that generates the undesired dependence with the size of the micro-scale. Once this detrimental effect has been identified, a solution is proposed that eliminates only the component responsible for the loss of objectivity in the macroscopic response, preserving the rest of the components of the inertial term, and therefore, the physical richness associated with the transient micro-structure. This proposal, using the Method of Multiscale Virtual Power (MMVP) as a theoretical framework and implemented by means of a squared finite element (FE2) computational scheme, offers a robust and coherent framework for the homogenization of transient phenomena, improving the reliability and applicability of multiscale modeling in engineering problems.

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