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ESHELBY-BASED ESTIMATES OF EFFECTIVE THERMAL PROPERTIES FOR MICROCRACKED MATERIALS

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Key Words: Microcracking, Thermoelasticity, Thermal conduction, Unilateral effect

Microcracks influence on the elastic properties of a material has been studied extensively through various modelling approaches. This paper aims to further the inquiry into thermal properties, considering both steady-state conduction and thermoelasticity. Taking into account the induced anisotropy (due to the oriented nature of cracks) and unilateral effect (different behaviour whether cracks are open or closed) remains an open research field. Using homogenization techniques, this work intends to present closed-form estimates of the effective thermal properties of a media weakened by arbitrarily oriented microcracks with unilateral behaviour.

One considers a 3D Representative Volume Element (RVE) composed of an isotropic matrix with randomly distributed families of parallel penny-shaped microcracks. Uniform macroscopic temperature gradient (for thermal conduction) and uniform macroscopic strain (for thermoelasticity) are applied on the outer boundary of the RVE. Open cracks are supposed to obey the adiabatic condition and are also stress-free. Following Deudé et al. [1], closed cracks are represented by a fictitious isotropic material accounting for some heat transfer and stress continuity. Works of Eshelby allow deriving microscopic temperature gradient and thermoelastic stress for ellipsoidal inclusions. Dilute and Mori-Tanaka schemes and Ponte Castañeda-Willis bound were thus developed owing that cracks aspect ratio tends towards zero.

All modelling representations show a cracks-induced anisotropy of the overall thermal conductivity [2] and thermoelasticity of the microcracked material. For both properties, the major degradation induced by a given family of open defects is obtained in the direction normal to these microcracks. Such influence depends also of the cracks density, the considered estimate and the related cracks spatial distribution. On the other hand, a family of closed cracks do not contribute to any degradation of thermal properties. Contrary to elastic properties, microcracks closure thus corresponds to the total deactivation of their influence on the conduction and thermoelastic behaviour of the material.

This study provides some relevant information to further develop a fully coupled thermo-mechanical model with evolving damage.

REFERENCES
