Porosity effects on elastic properties of polycrystalline materials: a three-dimensional grain boundary formulation

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Keywords: Polycrystalline materials, Micromechanics, Boundary element method , Porosity

Abstract. Polycrystalline materials are widely used in many technological applications of engineering interest. They constitute an important class of heterogeneous materials, and the investigation of the link between their macro and micro properties, main task of the micromechanics [1], is of relevant technological concern. The internal structure of a polycrystalline material is determined by the size and the shape of the grains, by their crystallographic orientation and by different type of defects within them. In this sense, the presence of internal voids, pores, is important to take into account in the determination of the polycrystalline aggregate properties.

Porosity exists in almost all materials to some extent and in particular in the polycrystalline ones; it is strictly depending by the conditions in which their construction techniques are set. However, sometimes it is desired for other than structural reasons such us, for example, heat transfer properties, radar reflection etc. For this reason the effects of porosity should be of concern to any polycrystalline material developed for a design. In particular, the macroscopic effects of the pores on polycrystalline materials elastic properties is of high interest and the Young and shear modulus are the major parameter to analyze in this case.

In this study the influence of porosity presence on the elastic proprieties of polycrystalline materials is investigated and a 3D grain boundary micro mechanical model for the analysis of porosity in polycrystalline materials is used [2]. Therefore, the volume fraction of porosity, pore size and their distribution can be varied to better simulate the response of a real porous materials to a given load. The formulation is built on a *boundary integral representation* of the elastic problem for the single grain, that is modelled as 3D linearly elastic orthotropic domain with arbitrary spatial orientation. The artificial polycrystalline morphology is represented using the Voronoi Tessellation. This algorithms, in fact, is widely recognised and used for the generation of microstructural model and it is simple to generate the statistical features of polycrystalline microstructures. The formulation is expressed in terms of intergranular fields, namely displacement and traction that play an important role in polycrystalline micromechanics.

References

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