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A yield criterion for porous single crystals based on limit analysis

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ABSTRACT

The ductile fracture of crystalline materials is a classical subject in mechanics of materials which still presents important challenges. It is driven by the process of growth and coalescence of voids and thus calls for constitutive models of the plastic response of porous crystalline materials. In this context, the consideration of the anisotropy, related to the single crystal response and the morphological and crystallographic textures of polycrystals, is a key issue. As compared to the studies on polycrystals, relatively few studies exist on the constitutive response of plastic single crystals containing voids. However, the importance of the crystalline anisotropy to describe the stress state surrouding intragranular voids has been clearly evidenced analytically, experimentally and numerically. The objective of this study is to derive a Gurson-type yield function for porous single crystals. Because of the widely spread finite-element (FE) implementations of the Gurson model, it would present an obvious interest to consider the case of single crystals deforming by crystallographic slip. With this aim in view, use is made of a regularization of the Schmid law. This key ingredient allows us to obtain a single yield function defining the plastic strength domain of voided single crystals. This feature is a definite advantage with respect to earlier proposals. The proposed criterion is assessed by comparison with results from the literature on unit-cell FE computations for Face-Centered Cubic single crystals with various orientations.