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A MULTI-SCALE APPROACH TO MODELLING ANISOTROPIC DYNAMIC RESPONSE OF TEXTURED POLYCRYSTALS

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ABSTRACT

Development of theoretical and simulation capabilities for modeling the high-strain rate stress strain response of pre-textured hexagonal close-packed (hcp) is essential for a variety of applications ranging from analysis of crash-worthiness and foreign-object damage in aerospace systems, ballistic and armor applications, high-rate forming and high-rate machining, etc. Historically, in order to keep the analyses tractable, only a minimal description of the material behavior was included by simplifying the material characterization down to just a few parameters. However, systematic experimental studies have shown that structure evolution in these materials is significantly altered by changes in strain rate and temperature as well as alloy and interstitial content and texture (e.g. [1]). While under quasi-static and dynamic loading conditions hcp materials may deform by slip and twinning, as the strain rate increases or temperature decreases the propensity of twinning becomes higher.

In this paper, a multi-scale methodology for describing the influence of evolving texture on the response of pre-textured hcp metals for dynamic loading conditions is presented. Texture evolution results from the strain path dependence of slip and twinning in this materials. To account simultaneously the anisotropy and compression-tension asymmetry associated with deformation twinning, yielding is described using a recently developed criterion [2]. The evolution laws for the strength differential and anisotropy coefficients involved in the model are obtained based on numerical tests performed with a polycrystalline model (VPSC model). Since this polycrystalline model incorporates explicitly the evolution of texture, we can thus obtain information concerning the deformation-induced anisotropy. An overstress approach is used to incorporate strain rate effects in the formulation. The model is applied to simulate the dynamic response of high-purity zirconium. The very good agreement between the finite-element (FE) simulations and experimental post-test geometries of the Taylor specimens in terms of major and minor side profiles and impact-interface footprints shows the ability of the model to describe the influence of twinning on texture evolution.

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