Asociación Argentina
de Mecánica Computacional

Mecánica Computacional Vol XXX, págs. 41-41 (resumen)
Oscar Möller, Javier W. Signorelli, Mario A. Storti (Eds.)
Rosario, Argentina, 1-4 Noviembre 2011

POLYCRYSTAL MODELING: A MECHANISM-BASED TOOL FOR SIMULATING PLASTIC FORMING OF COMPLEX METALS

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Abstract. The 'holy grail' of researchers performing simulations of plastic forming is a constitutive law that: 1) captures anisotropic response, hardening, and their evolution with deformation; 2) can deal with complex deformation histories that extrapolate beyond the strain mode, temperature and rate domains where the model was adjusted; 3) can be effectively implemented in Finite Element boundary value codes. Crystal plasticity (CP) models, based on the physical mechanisms of slip and twinning, meet at least the first two criteria, and are presently being pushed to meet the third criterion. CP models have advanced enormously in the last 25 years as a consequence of increased computational power, and notable advances in experimental methods of automated microscopy, neutron diffraction and synchrotron X-ray diffraction. These methods allow us to characterize material response and microstructure in great detail, challenge our modeling assumptions, and motivate us to develop increasingly sophisticated models.

In this talk I will describe the basics of crystal plasticity and CP models, and will present results of a comprehensive research program which focuses on linking modeling and simulation with experimental studies, at length scales spanning from the atomistic to the continuum. I will discuss applications to the low symmetry hexagonal metals Magnesium, Zirconium and Beryllium, which are plastically very anisotropic and cannot be modeled using standard material models such as Von Mises or Hill. I will show how this approach: 1) improves our understanding of the basic crystallographic deformation mechanisms in hexagonal metals and of the role that they play in plasticity; b) leads to an improved modeling capability based on such mechanisms.