Multiscale approach to describe the mechanical behaviour of Ti6Al4V alloys

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An experimental campaign was conducted on a 0.6 mm thick Ti6Al4V titanium alloy sheet. The performed tests were firstly *monotonic tests, i.e.*:

- uniaxial tensile tests along ten directions evenly distributed from rolling direction to transverse direction and along 45° direction
- simple shear tests along rolling, 45° and transverse directions
- plane strain tests along rolling, 45° and transverse directions
- simultaneous plane strain and simple shear tests
- biaxial tests and bulge tests

and secondly *tests with strain path change, i.e.*:

- Bauschinger tests
- orthogonal tests

The CPB06exn [1] macroscopic model was used to model the initial yield locus of the material. This phenomenological model is able to take into account the plastic anisotropy and the strength differential effect between tension and compression exhibited by hexagonal close packed metals. The material parameters were fitted on tensile and simple shear test data using the simulated annealing method [2]. Concerning the hardening, the modeling brings more difficulties. Indeed, an isotropic hardening model is unable to model all the experimental curves. It is required to use the shape and size evolution of the yield locus in order to reproduce all the tests. The crystal plasticity model, MULTISITE [3] helps to separate hardening due to texture evolution and hardening due to dislocation density distribution.

The MULTISITE hypotheses are (i) that the deformation of each grain is significantly influenced by the interaction with a limited number of adjacent grains, and (ii) that local strains deviate from their macroscopic average according to specific “relaxation modes”. The LAMEL model [4] is reformulated into the more general elastic-viscoplastic MULTISITE model permitting various relaxation modes.

The Lankford coefficients (r) measured and predicted by MULTISITE in all the tensile tests were analysed. In this study, different grain interaction hypotheses were tested. Based on experimental r_values and X-Ray Diffraction (XRD) measured textures, an identification of the critical resolved shear stresses (CRSS) of the different slip system families of the HCP and the strain rate sensitivity parameter was made. A comparison between the different models (TAYLOR, ALAMEL[4]) shows the efficiency of the latter one to predict different mechanical tests, such as tension tests, simple shear tests, plane strain tests, orthogonal tests and simultaneous plane strain and simple shear.

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