Study of the effects of α-grain proportion, shape and orientation on the mechanical behavior of Ti-5553 by FE simulations

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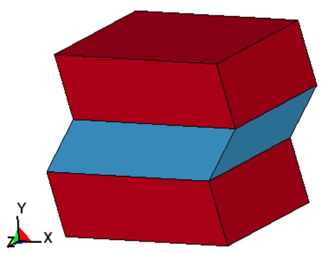
Ti-5553 is a new β metastable titanium alloy used in aeronautical applications. Ti-5553 involves, in general, a BCC β-phase and a hexagonal α-phase, with a morphology and distribution dictated by the thermal treatments. A.F. Gerday PhD thesis (Ulg 2009) investigated the material characterization of the two phases and also the numerical modeling of microscopic representative cells of this titanium alloy. The first aim of this paper is to study the influence of α-grain orientation on macroscopic behavior. The second aim consists in analyzing the effect of α-phase proportion inside the β matrix (at a microscopic level) on the global mechanical behavior (macroscopic level). This paper ended by studying the effect of grain alpha phase shape on the macroscopic behavior.

These studies are focused on the numerical modeling of representative cells of Ti-5553 alloy. This numerical investigation is realized using the periodic homogenization technique in Lagamine finite element code. A microscopic crystal plasticity-based constitutive law is used to model the flow properties of the α– and the β–phases. With such a constitutive law, the orientation of the grain(s) is taken into account and the different slip systems that can be activated are chosen with the corresponding critical shear stresses. A previous work [A-F, acta materialia] showed that the material behavior of this alloy is well represented by this mechanical model.

The material parameters of the model were identified using identification tests of the two phases. This identification was performed using macroscopic tensile and shear tests on 100% β and (α +β) materials and using nanoindentation tests in α and β grains of measured orientations.
α-β-grains interfaces constitute barriers to the movement of dislocations. The change in the α-grain proportion leads to the change of the number of barriers and so the mechanical behaviour. Different cells with different proportions (without changing α-grain orientation and shape) and different orientations and shape with fixed proportion are used.



Simulation of representative cell with 2 phases: α and β, result obtained at the end of the simulation