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Modelling of fracture in lamellar TiAl alloy based on a two-scale FE approach

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Recently, the multi-phase TiAl alloys have been implemented in low-pressure turbine blades of civil aero-engines. Current researches are focused on the improvements of alloy properties to expand the potentiality of this alloy for high temperature applications. As the deformation and fracture behaviour of this alloy are very sensitive to the microstructural features at different length-scales, one needs to understand the role of multi-phase aggregates and irregular grain morphologies to the micro-crack initiation and fracture behaviour at a micro and meso scale.

In this work we will present an approach of predicting fracture behaviour of two-phase (α_2-Ti_3Al + γ-TiAl) TiAl alloys with fully lamellar structure. Two-types of fracture have been considered, namely interlamellar and translamellar fracture. For the modelling purpose a unit-cell based two-scale finite element modelling has been developed, which takes into account the representative structural details of the alloy in micro and meso scale, crystal plasticity constitutive behaviour for the phase deformation, and possible fracture modes for describing interlamellar and translamellar fracture in the multi-phase constituents. The damage and fracture has been captured by implementing cohesive and XFEM approach in a FE framework.

The representative microstructural data for the model input has been evaluated via SEM and TEM analysis [1]. Experimental tensile fracture has been studied to identify the local fracture mechanisms. Some other missing data has been taken form the literature and calibrated via numerical modelling of deformation behaviour of a particular TiAl alloy [2].

In this work we will show some results on the microstructure sensitive prediction of crack initiation and propagation for oriented lamellar microstructures. Our results are in accord with the experimental observation at least qualitatively. However, further experimental investigations are required to adjust the model parameters for more accurate predictions.

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