

Observation of martensite phase transformation in shape memory alloys using a combined XRD-DIC technique

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Shape memory alloys (SMA), given to their pseudo-elastic behaviors and/or shape memory properties, have increasing industrial applications in domains such as robotic, medicine and aerospace. NiTi is probably the most widely used material for these alloys. However the potential coexistence of three principal phases (Austenite, Martensite, and R phase) depending on the thermo-mechanical loading conditions and exhibiting very different transformation deformation, makes the proposition of a robust multiaxial thermo-mechanical modeling a difficult task.

The combined DIC-XRD (Digital Images Correlation / X-Ray Diffraction) observation thus becomes extremely relevant for a precise evaluation, in terms of the characteristics and conditions of appearance for the phases, and for the validation of a model if it needs to be. Indeed tensile strengthening of such type of material is well known to develop multiple localized transformation bands. On one hand, DIC grants a continuous global observation of strain field and strain gradient at the interface between bands and matrix over a large region of interest (ROI) as function of time. On the other hand, a series of XRD scanning permit us to construct a spatial distribution of volume fraction for each phase.

Such experiment has been carried out on a quasi-equiatomic Ni-Ti 1D strip. By using proper optimization procedure, the experimental distribution of Austenite, Martensite and R phase has been identified at various strain levels, showing that the R-phase is always produced upstream of the production of the Martensitic phase. This distribution allows on the other hand the associated strain field to be evaluated by considering the free transformation deformation of each phase as a given data. This evaluation is shown to be in accordance with the strain field obtained by DIC. Experimental results are finally compared to the results of a finite difference thermomechanical modeling using a multiaxial and multiscale stochastic model as constitutive behavior.

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