NUCLEATION AND MOTION OF PHASE BOUNDARY IN SHAPE MEMORY ALLOY MICROTUBES

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Summary Helical-type martensite band nucleation and propagation in superelastic NiTi SMA microtube under tensile and torsional mechanical loadings are investigated. Using constitutive relation with intrinsic strain softening, 3D FEM simulation of the tube is performed to reproduce the observed phase boundary motion and deformation patterns. The results demonstrated the roles of material instabilities and the competition between bulk and surface energy in the observed martensite band morphology.

Helical-type martensite band nucleation and propagation in superelastic NiTi SMA microtube under uniaxial tension was observed recently as shown in the figure. This paper investigates this phenomenon from continuum mechanics point of view. Major results of the investigation on such pattern-forming deformation instability process during stress-induced phase transformation are summarized as follows. (1) Based on detailed experimental observation and possible deformation mechanism, a simple trilinear stress-strain relation with intrinsic strain softening is proposed to approximate the material constitutive behavior during stress-induced transformation. (2) Three-dimensional finite deformation simulation of the tube under loading was performed to model the detailed band nucleation and growth process. A combined analytical-experimental approach is used to extract the constitutive parameters of the material from the experimental measurement. The observed phase boundary motion and deformation patterns are successfully reproduced in the simulation by the identified trilinear constitutive law. The results demonstrated that only geometry instability due to finite deformation is not sufficient to quantify the experimental observation, both material and geometric instabilities, as well as the competition between bulk and surface energy play important roles in the observed martensite band morphology and its evolution. (3) Compared with the previous investigations based on a similar local constitutive theory, the issue of mesh sensitivity in the nucleation process of the martensite is addressed and demonstrated in the present simulation via the tube geometry. This important issue indicated that interfacial energy must be taken into consideration, which needs to be quantified by a non-local constitutive theory in the future investigation.

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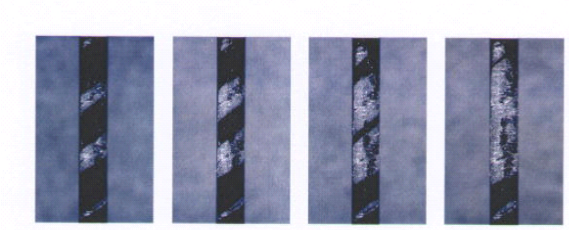
Helicity of martensite Band Morphology —— Experiment



Martensite helicoid —— FEM Simulation