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New aspects of structural and functional fatigue in shape memory alloys

The service lives of shape memory alloys (SMAs) are often limited by degradation processes. It is common to differentiate between structural and functional fatigue. Structural fatigue in SMAs represents a process where cyclic mechanical loading/unloading promotes the formation and growth of fatigue cracks, similar to what is known for conventional structural materials. In contrast, functional fatigue refers to a phenomenon where the accumulation of transformation induced defects affects the functional performance of the SMA in terms of transformation temperatures, changes in geometry and exploitable shape memory strain. Today, in actuator applications where SMAs have to tolerate a high number of functional cycles, another type of degeneration can lead to failure of a shape memory component. Even in the case of constant, but sufficiently high stresses, pure thermal cycling can result in the formation and growth of fatigue cracks. The phenomenon is often referred to as actuation fatigue or defect driven fatigue (DDF). In the present work, we present first results from a research project which aims for a better understanding of this phenomenon. We study how different alloy compositions and microstructures in SMAs affect defect generation/accumulation and the formation/growth of fatigue cracks under DDF conditions.

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