MODELING OF INTERNAL DAMAGE EVOLUTION DURING ACTUATION FATIGUE IN SHAPE MEMORY ALLOYS

F.R. Phillips[1], D.T. Martin[1], and D.C. Lagoudas[1,a]

[1]Aerospace Engineering and Materials Science and Engineering, Texas A&M University, College Station, Texas, United States of America
[a]lagoudas@tamu.edu

Abstract

Shape memory alloys (SMAs) are unique materials capable of undergoing a thermo-mechanically induced, reversible, crystallographic phase transformation. As SMAs are utilized across a variety of applications, it is necessary to understand the internal changes that occur throughout the lifetime of SMA components. One of the key limitations to the lifetime of a SMA component is the response of SMAs to fatigue. SMAs are subject to two kinds of fatigue, namely structural fatigue due to cyclic mechanical loading which is similar to high cycle fatigue, and functional fatigue due to cyclic phase transformation which typical is limited to the low cycle fatigue regime. In cases where functional fatigue is due to thermally induced phase transformation in contrast to being mechanically induced, this form of fatigue can be further defined as actuation fatigue. Utilizing X-ray computed microtomography, it is shown that during actuation fatigue, in- ternal damage such as cracks or voids, evolves in a non-linear manner. A function is generated to capture this non-linear internal damage evolution and introduced into a SMA constitutive model. Finally, it is shown how the modified SMA constitutive model responds and the ability of the model to predict actuation fatigue lifetime is demonstrated.

Keywords: SMAs, low cycle fatigue, thermally induced, X-ray μCT, damage evolution