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M2Or2A-05: First Approximation for Unified Fatigue Models for 316 Stainless Steel and IN718 Materials at 4K, 77K & 293K from Monotonic Material Properties

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Fusion applications utilizing magnets require the use of materials that are capable of withstanding the cyclic electromagnetic forces during startup and shutdown at cryogenic temperatures. Because of the cyclic nature of loading, a fatigue model is essential to characterize the capability of these parts to determine operational life and prevent premature component failure. Thus, there is a need for test data at low temperatures, specifically at 77K and 4K, corresponding to the temperatures of liquid nitrogen and helium, respectively. However, testing at such conditions is very expensive, requiring proper containment, sufficient coolant supply, and load / strain monitoring throughout the life of the test. Thus, the initial approach to this effort is to conduct a literature search to establish a preliminary foundation of available fatigue data, then supplementing the database with additional testing as needed. At this time, the data from the literature search has been successfully fit at three temperatures (4K, 77K, and 293K) to a standard Manson-Coffin-Basquin model with a typical to min scatter under 7.0. Additional work has been done to apply this data to a hardness-based lifing approach, which proposes that fatigue behavior can be sufficiently characterized using monotonic properties, at least to a first approximation. Preliminary results for this approach have been successful for both 316 type stainless steel and Inconel 718, resulting in conservative but reasonable fatigue estimates for both room and cryogenic temperatures.

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