Estimation of Uncertainty for Fatigue Growth Rate at Cryogenic Temperatures

Arman Nyilas[1], Klaus P. Weiss[2], Elisabeth Urbach[2], Dawid J. Marcinek[3]

[1]Cryogenic Engineering & Materials Expertise, CEME
76297 Stutensee, Germany
[2]KIT, Karlsruhe Institute of Technology, D-76344
Eggenstein-Leopoldshafen, Germany
[3]CERN-European Organization for Nuclear Research,
CH-1211 Geneva 23, Switzerland

ABSTRACT - Fatigue crack growth rate (FCGR) measurement data for high strength austenitic alloys at cryogenic environment suffer in general from a high degree of data scatter in particular at ΔK regime below 25 MPa√m. Using standard mathematical smoothing techniques forces ultimately a linear relationship at stage II regime (crack propagation rate versus ΔK) in a double log field called Paris law. However, the bandwidth of uncertainty relies somewhat arbitrary upon the researcher's interpretation. The present paper deals with the use of the uncertainty concept on FCGR data as given by GUM (Guidance of Uncertainty in Measurements), which since 1993 is a recommended procedure to avoid subjective estimation of error bands. Within this context, the lack of a true value addresses to evaluate the best estimate by a statistical method using the crack propagation law as a mathematical measurement model equation and identifying all input parameters. Each parameter necessary for the measurement technique was processed using the Gaussian distribution law by partial differentiation of the terms to estimate the sensitivity coefficients. The combined standard uncertainty determined for each term with its computed sensitivity coefficients finally resulted in measurement uncertainty of the FCGR test result. The described procedure of uncertainty has been applied within the framework of ITER on a recent FCGR measurement for high strength and high toughness Type 316LN material tested at 7 K using a standard ASTM proportional compact tension specimen. The determined values of Paris law constants such as C0 and the exponent m as best estimate along with the their uncertainty value may serve a realistic basis for the life expectancy of cyclic loaded members.

KEYWORDS - Uncertainty, 316LN, fatigue crack growth rate, cryogenics PACS: 62.20. me

IEEE/CSC & ESAS SUPERCONDUCTIVITY NEWS FORUM (global edition), July 2013
Manuscript 1MOrD1-01 submitted to CEC/ICMC Proceedings in AIP Conference Proceedings, Reference No. ST344; Category 5: preprint accepted by SNF on July 18, 2013