A time dependent equivalent stress function for proportional and non-proportional transient loaded and notched metallic components

H. Mertens, R. Liebich

PII: S0142-1123(17)30253-0
DOI: http://dx.doi.org/10.1016/j.ijfatigue.2017.06.003
Reference: JIJF 4359

To appear in: *International Journal of Fatigue*

Received Date: 6 April 2017
Revised Date: 1 June 2017
Accepted Date: 5 June 2017

Please cite this article as: Mertens, H., Liebich, R., A time dependent equivalent stress function for proportional and non-proportional transient loaded and notched metallic components, *International Journal of Fatigue* (2017), doi: http://dx.doi.org/10.1016/j.ijfatigue.2017.06.003

Heinz Mertens Robert Liebich

A time dependent equivalent stress function for proportional and non-proportional transient loaded and notched metallic components

Mertens H
School of Mechanical Engineering and Transport Systems, Technical University of Berlin, Institute of Engineering Design, Micro and Medical Technology, Chair of Engineering Design and Product Reliability, Sekr. H66, TU Berlin, Strasse des 17. Juni 135, 10623 Berlin, Germany

Liebich R (corresponding author)
School of Mechanical Engineering and Transport Systems, Technical University of Berlin, Institute of Engineering Design, Micro and Medical Technology, Institute of Aeronautics and Astronautics, Chair of Engineering Design and Product Reliability, Sekr. H66, TU Berlin, Strasse des 17. Juni 135, 10623 Berlin, Germany, robert.liebich@tu-berlin.de, fon +49(0)30 314-22335, fax +49(0)30 314-26131

Abstract

The novel "Modified Mohr Mises" (MMM) Hypothesis allows the assessment of non-proportional stresses within a fully automated process, due to its invariant equivalent stress notation. Those non-proportional stresses are most common in complex structures of aircrafts, spacecrafts and vehicles for instance. The new MMM Hypothesis provides a physically reasonable sign determination derived directly from the effective stress components. Supporting effects through material and adjacent material areas and local geometries are considered in the theory as well. The use of a suitable tension shear strength ratio allows a consideration of anisotropic material behavior in the surface as well. The MMM Hypothesis and its predecessors were formulated to support the development of the fatigue strength assessment of the German FKM Guideline, in order to be able to utilize, among others, the Guideline material-related knowledge for non-proportional components with load-free and fluid-loaded, smooth and notched component surfaces.

Keywords fatigue, multiaxial fatigue, non-proportional loading, MMM Hypothesis, Mises-Hypothesis, sign

Nomenclature

$\sigma_{eq,MMM}$	equivalent stress	V	sign function
R_M, R_M^{oo}	invariant, auxiliary invariant	M_M , $M_{M,plane}$	invariant, invariant of surface plane
k_a	tension shear strength ratio	η	dimensionless time
m_a, m_{a1}, m_{o1}	macro-supporting factor	n_{el}	micro-supporting factor
$\sum$	stress tensor	$\sigma_x, \sigma_y, \tau_{xy}$	stress components
$\sigma_{1,2,3}$	principle stresses	$\Delta\sigma$	range of normal stresses
ψ	principle axis angle	$\sigma'_{eq,a}$	equivalent stress amplitude w/o sign or supporting effects
$\sigma'_{eq,MMM}$	equivalent stress w/o supporting effects		
$\hat{\sigma}_{a1}$	highest alternating principle stress	$\hat{\sigma}_{o1}$	highest maximum principal stress
$\sigma_{eq,m}$	equivalent mean stress	$\sigma_{eq,a}$	equivalent stress amplitude
φ	constraint factor	χ	normalized equivalent stress gradient of $\sigma'_{eq,MMM}$
N, N_E	load cycle, endurance limit load cycle	N_{old}	auxiliary load cycle for iteration
$\sigma_{-1,N}$	endurance limit	°	indicates basic data (FEM, BEM)
$\check{\sigma}, \check{\epsilon}$	lower Neuber stress, strain level	$\underline{\hat{\sigma}}, \underline{\hat{\epsilon}}$	effective Hooke stress, strain