International Journal of Fatigue 137 (2020) 105643

Contents lists available at ScienceDirect

International Journal of Fatigue

journal homepage: www.elsevier.com/locate/ijfatigue

Fatigue calculation for transient proportional and non-proportional multiaxial vibrational stress for component optimisation based on the Modified Mohr-Mises-Hypothesis

Heinz Mertens (Prof. Dr.-Ing.) (Former head of department), René Kamieth (Dipl.-Ing.) (Research assistant), Robert Liebich (Prof. Dr.-Ing.) (Head of department)*

Technische Universität Berlin, Chair of Engineering Design & Product Reliability, Institut für Maschinenkonstruktion und Systemtechnik, Sekr. H66, Straße des 17. Juni 135, 10623 Berlin, Germany

ARTICLE INFO

Keywords:
Fatigue analysis
Modified Mohr-Mises-Hypothesis
Rainflow count
Sign function

ABSTRACT

The Modified Mohr-Mises-Hypothesis (MMMH) allows fatigue analysis in a broad scope: notched and unnotched metallic parts made of homogenous ductile or brittle materials, under oscillating, multi-axial and transient proportional or non-proportional loads. It is the result of 30 years of research with multiple publications which validated its core concepts. Its novelty lies in the conservation of relevant signs and inclusion of factors for nonlinearity. Now, a post processing method has been added using Rainflow count for periodic processes. By considering the mean stresses through load cycle-based Haigh diagrams an equivalent stress is calculated. This enables a practical linear fatigue analysis.

1. Introduction

The Modified Mohr-Mises Hypothesis (MMMH) has been in development and under validation for several decades. It applies to:

- Notched and unnotched parts
- Metallic, homogenous materials
- Materials ranging from ductile to brittle
- Oscillating loads
- Multi-axial loads
- Transient loads
- Proportional and non-proportional loads

The hypothesis aims to offer a tool for comprehensive fatigue analysis, complementary or alternative to the methods from established standards. Its novelty compared to e.g. the use of the equivalent stress according to v. Mises is the mathematical determination of the correct sign dependent on the oscillation process and the inclusion of non-linearities with suitable factors.

The paper gives an overview over past research into the MMMH and places it in scientific and practical context. A post processing method is then introduced which allows the processing of MMMH stress history data in order to calculate a cumulated damage and its corresponding service life. As a practical example simulated stress from a wind turbine rotor hub is used.

The overall concept for fatigue analysis based on the MMMH is summarised in this paper:

- First of all, the state of the art and an overview over the MMMH is given in sections 2 and 3.
- The detailed post-processing calculations presented in the following sections use a previously determined MMMH equivalent stress history. This preliminary calculation, which is not shown in detail here, is based on the procedure explained in chapter 3.
- A Rainflow count for periodic processes for the determination of the amplitudes and mean stresses of the individual counted hysteresis loops follows.
- The mean stresses are eliminated using load cycle-dependent Haigh diagrams.
- In order to demonstrate the approach for transient stress a fictional equivalent stress time series is generated based on a simulated one for the rotor hub of a wind turbine.
- Using the different Miners' rules for linear damage accumulation the respective damage sums D are calculated. The difficulty of the admissible damage sum according to Miner is discussed on the basis of the assessment of the variable amplitude fatigue strength of the FKM guideline [8].

* Corresponding author.
E-mail address: robert.liebich@tu-berlin.de (R. Liebich).

https://doi.org/10.1016/j.ijfatigue.2020.105643
Received 16 January 2020; Received in revised form 7 April 2020; Accepted 7 April 2020
Available online 12 April 2020