Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 213 (2018) 788–796

Procedia Engineering

www.elsevier.com/locate/procedia

7th International Conference on Fatigue Design, Fatigue Design 2017, 29-30 November 2017, Senlis, France

Fatigue lifetime estimation of bearing pin of console manipulator loaded with multiaxial random loading.

Matúš Margetin[a,]*, Miroslav Šulko[a]

[a]Slovak university of technology – Faculty of mechanical engineering, Bratislava 812 31, Slovakia

Abstract

Fatigue lifetime estimation of load bearing parts of construction is a key factor in a design of technique used for long term operation. Complex loading in combination with complex geometry of the most loaded parts represents only one of many problems that engineers have to deal with. One of the most commonly used approaches how to deal with this problem is to use the technical standards. This approach, despite its indisputable advantages (clear and comprehensible steps of calculation), has several significant shortcomings (non-economical oversized design). In this paper we propose procedure of how to estimate fatigue lifetime of construction parts that are loaded with random operational loading. The result of proposed procedure is distribution function of fatigue lifetime which takes into account the complex geometry of the designed part and random character of the complex loading (multiaxial stress state) in a hotspot. This approach is then demonstrated on fatigue lifetime estimation of bearing pin of a console manipulator loaded by random operational loading. Loading process was obtained using set of strain gages. The measured loading process was then transformed into stress histories in critical hotspot using FEM. Method of processing the stress loading histories in critical hotspot into a form usable in combination with hypotheses for fatigue damage calculation under multiaxial stress states is presented.

Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.

Keywords: multiaxial fatigue; variable amplitude; nonproportional loading

* Corresponding author. Tel.: +421903294884;
*E-mail address:*margetin.matus@stuba.sk

1877-7058
Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.
10.1016/j.proeng.2018.02.074

1. Introduction

Estimation of fatigue life time of mechanical components working under real operational loadings (usually multiaxial variable amplitude loading) could be considered as an ultimate task in a field of fatigue life time analysis. Due to the complexity of the problem, there are many factors that have crucial influence on the final lifetime estimation. Moreover, a great deal of these problems do not have widely accepted solution and usually there are multiple ways how to solve them. One way how to tackle these problems is to use the methodology given by standards. These standards normally use some simplification to make the estimation more feasible for engineers. However, as a result of these simplifications, the methodology given by standards is normally suitable only for infinite life calculation, and when used in finite fatigue life time estimation, it usually leads to oversized components, or in some cases, it can even lead to the design error on non-conservative side. Due to these facts, enormous effort was and still is put forth to postulate methodology for finite fatigue life estimation under variable non-proportional random loading [1,2,3,4,5]

Nomenclature

σ_f'	Fatigue strength coefficient
b_σ	Fatigue strength exponent
τ_f'	Shear fatigue strength coefficient
b_τ	Shear fatigue strength exponent
k_{fin}	Findley criterion parameter
τ_f^*	Findley shear fatigue strength coefficient
σ_x, σ_y	Normal stress component
τ_{xy}	Shear stress component
$\sigma_{x'}$, $\sigma_{y'}$	Normal stress component in rotated coordinate system
$\tau_{x'y'}$	Shear stress component in rotated coordinate system
M	Bending moment
M_x	X-component of bending moment
M_y	Y-component of bending moment
α	Angle of bending moment orientation
τ_{eq}	Equivalent shear stress amplitude
σ_a	Normal stress amplitude
σ_n	Normal stress acting on plane
σ_{max}	Maximal normal stress acting on plane
τ_a	Shear stress amplitude
τ_{am}	Shear stress amplitude with nonzero meanvalue
τ_m	Shear stress mean value
N_f	Number of cycle to failure
CI	Confidence interval
N_{fi}	Number of cycle to failure corresponding to i-th amplitude
n_i	Number of occurrence
D	Damage
β	angel between critical place and coordinate system of measured bending moment

In the pages below, authors show how to deal with problems that engineers have to overcome during fatigue life time estimation under multiaxial random loadings. Step by step, analysis of real component (bearing pin of pneumatic handler) loaded with random loading is shown. Usage of multiple techniques is shown for various problems and brief comparison of results and small critical discussion is provided.