Dissertation Thesis Review

Institute: INSTITUTE OF SOLID MECHANICS, MECHATRONICS AND BIOMECHANICS, Faculty of Mechanical Engineering, Brno University of Technology

Thesis title: Transferability of fatigue crack propagation data between bodies with different sizes and geometry.

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Thesis Opponent: Ing. Zdeněk Chlup, Ph.D.

Topicality, relevance, and originality

The prediction of fatigue life has been the aim of the scientific and engineering community for decades. The thesis addresses the transferability of data on crack propagation, a very important scientific topic with practical applications. Also, the link to the railway axle application underlines the relevance of the work. The development of new methodologies of lifetime prediction, data filtration and statistically based simulations provides an original set of findings.

Scientific Quality

The thesis is divided into three subtasks, each of which can be evaluated as stay alone. First, dealing with the threshold of stress intensity factor is important for the fatigue life prediction. The scientific benefit here is that the author separated the effect of oxidic crack closure, bringing new insight to the description of the threshold value. This decomposition enables more accurate threshold predictions for components exposed to different environments and load histories.

Second, brings insight into the effect of residual stresses in the welds, which is not reliably measurable nor included in the fatigue life predictions. The concept presented uses nonstandard specimens with artificial defects. The findings pinpointed directions of further development in this very complex field.

The third area investigated within the thesis is focused on to stochastic description of the fatigue crack behaviour based on a batch of available data. Through the developed a

robust Monte Carlo simulation-based stochastic framework for residual fatigue life is possible to determine the inherent scatter in fatigue data due to many factors as microstructural heterogeneity, environmental variation/humidity, and measurement uncertainties.

The overall scientific quality of the thesis is on a high level and meets standards for this type of work.

Formal Aspects

The structure and organisation of the thesis are on a high level; however, some imperfections can be found, especially in the non-detailed description of simulation approaches, experimental procedures used, etc. This can be excused by the width of three topics itself, where additional information would be extremely elongated the thesis itself. The way would be to link the annexes containing relevant information. The language and its style are at a high level without significant errors. Unfortunately, frequently micrographs have been presented without a size marker (e.g. Fig. 2.5, 5.3, 5.7, 5.8, 5.12 ...), therefore, it is hard to imagine the dimensions of observed objects, or in some cases also graphs are with missing or incomplete legends (e.g. Fig. 2.9, 6.3, 7.5 ...). Another important aspect can be recognised in the large amount of data used in the work, where the source is not precisely defined, and it is not clear which data were obtained within the framework of the PhD study. Nevertheless, the work was rather focused on the data analysis, simulations and building methodology than obtaining a high amount of experimental data. More than 200 literature sources were used, most of them in the theoretical section of the thesis, resulting in scientific gaps and the formulation of objectives.

Objectives

The author defined four main objectives of the work, containing sub-goals. It can be stated that all goals were fulfilled.

Overall Assessment

The dissertation thesis is timely, and it attacks an industrially attractive topic with a focus on the environment-sensitive, probabilistic approaches for fatigue life time prediction. Particularly, it brings new solutions or methodology in oxide-induced closure of the fatigue crack by threshold stress intensity factor decomposition, application of semi-elliptical-crack threshold measurement and transferability of such data, and also residual-stress affected life prediction for welds. The findings shown need to be

generalised and validated for a broader materials pool. Nevertheless, the work advances both scientific understanding and engineering practice, and it opens concrete pathways for safer, cost-effective inspection regimes across the rail and pressure-vessel sectors.

Based on the mentioned criticism, I would like to recommend Ing. Dušan Tichoň for the award of a Ph.D. degree.

Questions

Q1: What will be the effect of other components of the description of the crack tip stress field by Williams on the threshold values determined for various specimen/component sizes? Especially for the transferability of subsided specimens (like mini-CT) to the real components (as a pressure vessel).

Q2: How will it affect the results when not only humidity will be considered, but also salinity (maritime climate) in the case of a railway axle, or a hydrogen-rich environment in the case of the power generation applications?

Q3: How will the application of the mentioned approaches be affected by temperature? The yield strength, ultimate tensile strength, fracture toughness, etc., are for structural steels that significantly vary with temperature.

In Brno, June 26th 2025

Ing. Zdeněk Chlup, Ph.D.