REVIEW OF DOCTORAL THESIS

Approximate Methods for Calculating Notch Tip Strains and Stresses Under Multiaxial Cyclic Loading

Author: Ing. Maxim Lutovinov

The thesis prepared under the supervision of prof. Milan Ruzicka and Ing. Jan Papuga deals with new ways to evaluate the history of notch tip plasticity under multiaxial cyclic loading, while the starting point of such evaluation is a simple elastic FE analysis. This is still an actual problem to be solved, as it is not acceptable, from practical point of view, to realize full elastic-plastic FE analysis of fatigue for large structures. Having this in mind, the principal aim of the thesis was formulated as the development of a new, pseudo-curve based approximative method for calculation of notch-tip elastic-plastic stresses and strains under multiaxial cyclic loading. This aim is split into three subsequent steps, namely the

- Development of the methodology how to combine the notch correction and plasticity model, with detailed description and implementation code
- Proposal of new approximate method for calculation of elastic-plastic strains and stresses at the notch tip, comparable to or better than other existing methods
- Validation of the proposed method on new experimental data from material other than steel, including experiments with non-zero mean stress loading path

According to the reviewer`s opinion, **all these goals were reached**.

State of the art is described in the Chapter 2 in a concise and structured way. Existing approximate methods for notch tip plasticity in monotonic and cyclic loading are shown and different plasticity models are presented and critically commented. The analysis presents a **valuable introduction to the problem solved** and **shows a very good orientation of author in the topic of his dissertation**.

The author used for the approximate evaluation of stress and strain an advanced Abdel-Karim-Ohno model of plasticity. The algorithm was implemented in MATLAB and it is capable to convert an elastic FE solution of multiaxial notch loading to elastic-plastic solution. Knowledge of cyclic deformation curve of the material is necessary for this conversion. Full listing of the MATLAB procedures is provided in the Appendix C of the dissertation. The algorithm was validated on the example of 2124-T851 aluminium alloy with

a large experimental program of ten different multiaxial loading paths, including non-zero mean stress, with two different notch shapes. The results are presented in the Appendix A. Besides the original experiments on aluminium alloy, other verification was realized using material data of 1070 steel from literature. These results were also compared with independent approximation of notch plasticity by another authors and methods, as presented in Appendix B. All the results show that the **author used appropriate methods** to solve the problems and that he **applied them properly**. The application of mentioned methods covers a large span of activities, from theoretical areas over programming up to demanding experiments. I would like to ask the author for the proportion of his personal participation in each of those activities.

The contribution of the presented dissertation can be seen in several areas. **In theory**, the dissertation formulates a **new methodology of approximative solution of stress and strain history at the notch tip under complex multiaxial loading**. Moreover, this methodology is formulated in the form of MATLAB code and verified successfully by a large set of real experiments on aluminium alloy. **The practical importance is in the developed code**, which is at disposal for further evolution of the research of cyclic plasticity modelling. **Great practical meaning is also in the experimental results of the new material data of aluminium alloy 2124-T851**, which represent an original outcome of the dissertation.

The formal level of the dissertation meets all standard demands. It is written in good English, the text, tables and figures describe the topic in a clear and understandable way. The theoretical introduction and state of the art could be expressed in more detail, the same is true for the final discussion of results. Nevertheless, the appendices contain all important experimental results in comparison with the computational simulation as well as a full text of MATLAB script of the notch tip plasticity approximation. As a whole, the **dissertation is presented as a well-structured scientific text** and **I propose it for defence** at the examination body of Mechanics.

In Brno, May 30, 2022

prof. Jindřich Petruška

Inst. of Solid Mechanics, Mechatronics and Biomechanics

Faculty of Mechanical Engineering

Brno University of Technology