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FATIGUE UNDER FRETTING CONDITIONS

M. Španiel, M. Nesládek, J. Jurenka, J. Kuželka, J. Růžička*

Abstract: *Presented paper deals with application of phenomenological fatigue criteria on fatigue under fretting conditions. The objective is evaluation of fretting fatigue based on phenomenological criteria calibrated with relatively small set of experiments. Numerical stress analysis using finite element method was used (as usual in engineering applications) to determine stress fields and relative slips in contact interface of specimen in experimental set up. These quantities serve as input to several fatigue criteria that are to be compared each to other and evaluated. Optical measuring system DANTEC DYNAMICS Q-450 employing digital image correlation method for displacement field evaluation was used to calibrate and verify numerical model of friction. Basic results of experiments and computations are presented to be discussed.*

Keywords: ***Fatigue, fretting.***

1. Introduction

The target of presented research is to evaluate fatigue damage under fretting conditions. Evaluation is based on phenomenological criteria the verification of which should be based on reliable experimental and computational results. Quantities describing local material loading as stress field, contact slips etc., the measurement of which is very difficult, are in practice often calculated using finite element method. It is dependent on phenomenological description of friction. That is why we decided to verify and identify numerical model of experimental set up from the point of view of friction.

2. Experimental and numerical research

We have designed, manufactured and tuned up experimental set up utilizing electromagnetic pulsator AMSLER. Series of fatigue experiments under fretting conditions was carried out on the set up. Moreover the measurement of contact slips using digital image correlation optical method was implemented. To obtain required input data for the fatigue criteria, a 3D FE model of the testing apparatus was assembled and analysed. FE solver Abaqus was used for the numerical simulation. Various multi-axial fatigue criteria were employed to evaluate experimentally measured fretting fatigue based on plain fatigue parameters of specimen material. Fatigue index approach has been utilized so far. To compare various criteria, fatigue index error was evaluated in small domains in vicinity of contact for loading representing experimentally determined fatigue limit for set of criteria including Crossland (Cross), Sines (Sin), Kakun-Kawada (KK), Dang Van (DV), Gonçalves, Araújo, Mamiya (GAM), Mamiya (Mam), Papuga (PCr). These criteria are well described in Papuga (2011). Fatigue index errors for these criteria are printed in table 1.

3. Conclusions

Series of 31 test simulating fretting fatigue conditions was done using flat dog bone samples from heat resisting chromium steel. Based on S-N curves of fretting tests and plain fatigue tests comparison significant negative effect of fretting on lifetime of samples can be observed. No significant influence of various transversal pressure load of contact pads by values of $5\,\mathrm{kN}$ and $15\,\mathrm{kN}$ on life of samples could be seen. Significant variance of number of cycles to crack initiation for different specimens with the same

*Associate Prof. Ing. Miroslav Španiel, CSc., Ing. Martin Nesládek, Ing. Josef Jurenka, Ing. Jiří Kuželka, Ing. Jan Růžička
Faculty of Mechanical Engineerig, Czech Technical University in Prague, Technická 4; 166 07, Prague; CZ, e-mail: miroslav.spaniel@fs.cvut.cz

Tab. 1: Fatigue index error values for the selected multiaxial criteria.

	Fatigue index error ΔFI [%]						
P [kN]	Cross	Sin	DV	KK	GAM	Mam	PCr
5	2.1	-35.4	6.8	-6.8	14.9	12.7	14.8
15	25.1	-8.3	21.8	19.4	57.7	54.0	27.2

loading probably follows from 1) non uniformly distributed contact pressure; 2) Initial surface roughness with possible surface defects from machining; 3) Other factors, especially boundary conditions. The closer the load approaches fatigue limit, the more significant variance appear. Measured S-N curves served as base of verification of the ability of various HCF multi-axial criteria to predict fatigue failure under fretting conditions. Stress fields analysed by FEM were used as input into these fatigue criteria. Fatigue index error was used as measure of criteria quality. This research resulted into some hints and hypotheses:

1. Elastic-plastic material model in FE calculations provides us with much better fretting fatigue predictions.
2. The best correspondence can be seen for Crossland and Dang Van criteria. For pressing force $P = 5\,\mathrm{kN}$ fatigue index error approaches almost zero. For $15\,\mathrm{kN}$ it is conservative. This tendency have shown all tested criteria.
3. All tested criteria except the Sines one are conservative. That is why the Sines criterion cannot be recommended.
4. Tested criteria do not evaluate the influence of pressing force correctly. While the experiments have not shown any difference in the life of flat dog bone specimens under pressing force $P = 5\,\mathrm{kN}$ and $P = 15\,\mathrm{kN}$, the criteria have. It would be appropriate to consider some correction of criteria based on correlation of life and contact slips. Establish a reliable correction would require a further series of experiments with different pressing forces.

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