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QF MARKER RESEARCH

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Main research questions

a) How to define and add marker blocks to a given real usage spectrum of a fighter aircraft
b) Former in terms of effects on both small aluminium specimens and full-scale fatigue tests
c) Former two without affecting the structural lifetime of a test article
d) Applicability of QF and optical microscopy (OM) in analysing small crack growth

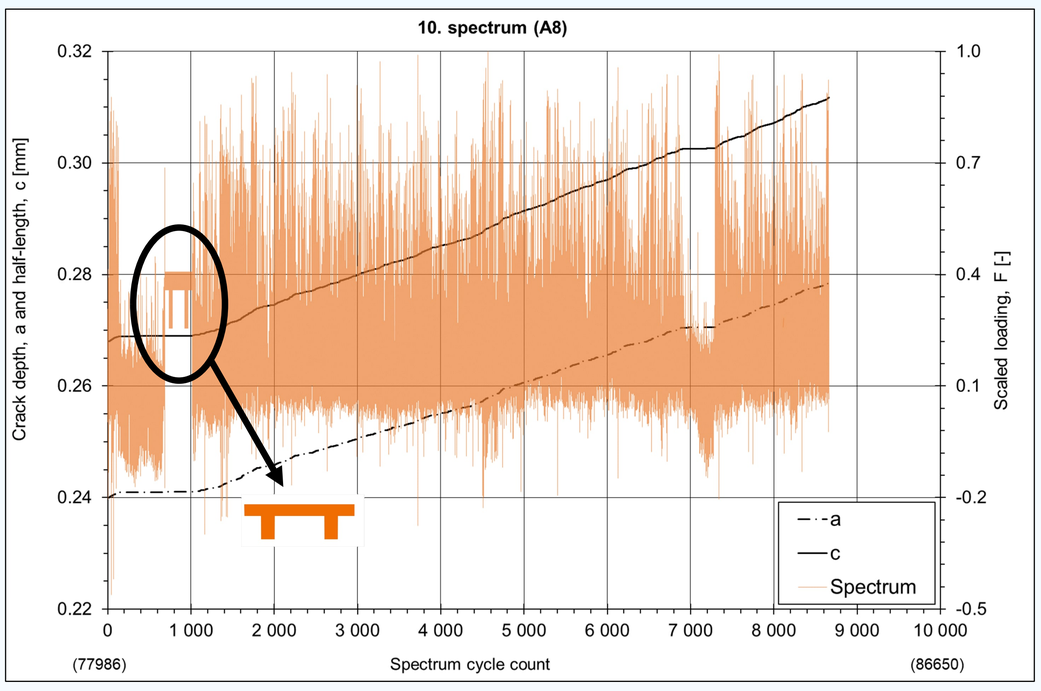
The future research question is how to use machine learning to automate the marker identification process

Defining and adding marker loads

An attempt can be made to estimate the crack growth rate by observing the number of test spectra along the crack. If there are no natural marker loads within the spectrum itself that would already leave traces on the fracture surfaces suitable for observing spectrum repetitions, at least one additional marker load area, with minimal effect on structural lifetime, must be inserted into the spectrum. Preliminary design work of marker loads for the spectrum and small aluminium specimens is based on an extensive literature review. Changes in load ratios and constant amplitude blocks were chosen as marker load types to be further investigated in this study.

Computational fatigue life estimates

Crack growth calculation results showed that the pre-designed marker block versions do not have an influence on the fatigue life estimates with the computational parameters selected for the analyses.

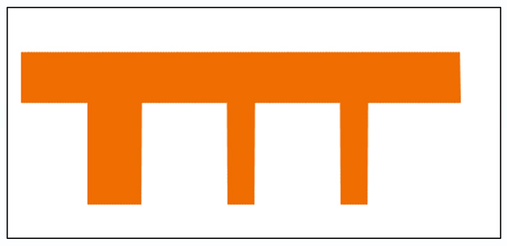


Computational crack growth time histories with respect to spectrum with added “A8” marker loads when calculation is at 10th spectrum

Testing of marker loads

To ensure the readability of the markers, a pilot set was carried out with several different marker load blocks and frequencies of the marker load spectrum. Joint specimens to be tested were selected among an extensive fatigue test series. The “A7” marker load block version was decided to be used as the added marker load type for the actual fatigue test series. Based on the results, the chosen marker block is not affecting the structural fatigue test lives of the specimens. In testing, every fifth spectrum contains added marker loads.

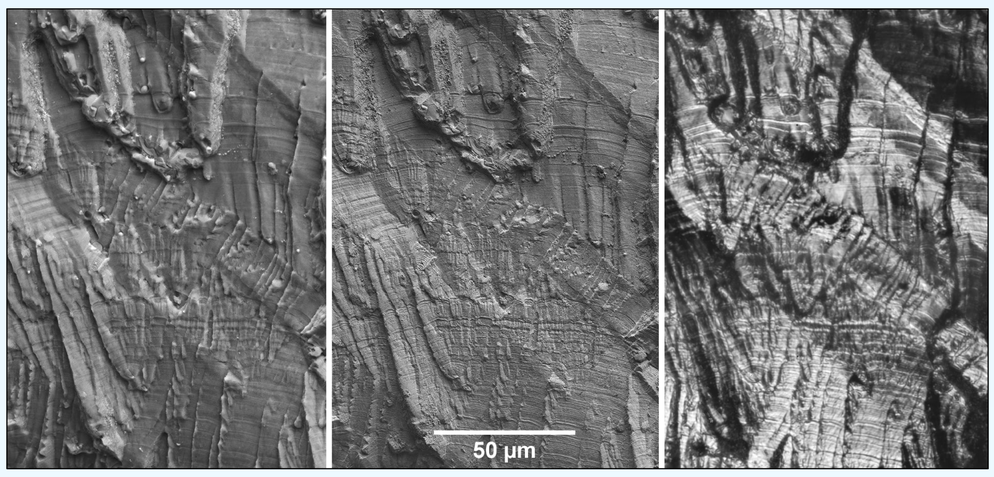
From top: MLT1, MLT2, and LLT aluminium 7075-T76 ESDU specimen types to be tested



Marker load block type “A7”, which was introduced in extensive fatigue test series

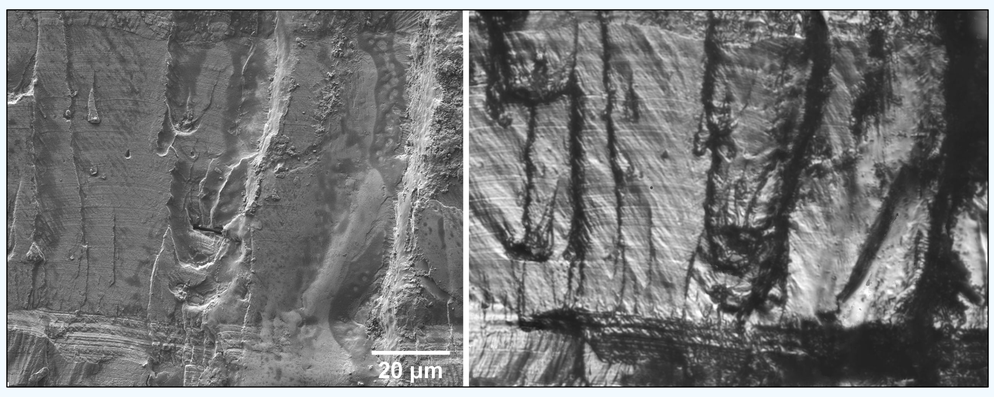
Preliminary findings

- Significantly higher resolution (SEM) is helpful for the initial identification of marker bands
- SEM has better depth of field, but with OM, images of a fracture surface at different focal planes can be acquired and combined into a single high-depth-of-field image
- OM has a significantly faster analysis time
- OM has the possibility to utilize varying tilting angles to reflect light back at the objective lens in different ways



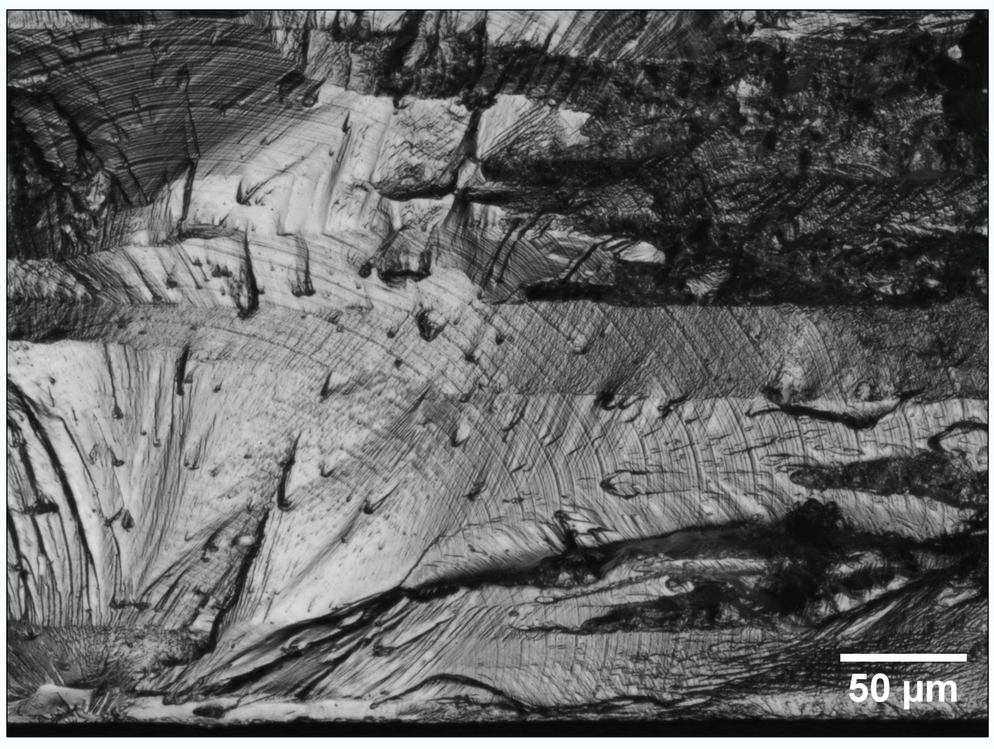
Left and mid: SEM with different accelerating voltages, right: OM

- No significant added benefit with SEM while tracing the crack progression
- Instead of single fatigue striations, features of interest are wider marker load bands



In some areas striations can be distinguished better with OM

- Question is whether the trackability of marker bands at small crack sizes remains appropriate or not
- If not, is it still possible to extrapolate crack growth curves towards small crack sizes and achieve better calculation parameters for fracture mechanics to some extent
- If true, in this context, the choice between microscope types should be made in terms of usability and operating speed



Clearly distinguishable crack progression marks at low crack depth (OM)

- Initial expectation (OM) is roughly a 25–50 % reduction in working time compared to SEM, but even more reduction can be achieved if the analyst is familiar with the marker band

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