

In-situ 3D study of fatigue crack growth with overload effects in AlSi alloy

Lucas Sanciet--Munier^{1*}, Nathalie Limodin¹, Jean-Yves Buffière², Jean-François Witz¹, Michel Coret³, Ghita Bahaj Filali³, Yves Gaillard⁴, Michel Fleuriot⁴, Arnaud Weck⁵

¹ Univ. Lille, CNRS, Centrale Lille, UMR 9013 - LaMcube - Laboratoire de Mécanique, Multiphysique, Multi-échelle, Lille, F-59000, France

² INSA Lyon, MATEIS, F-69621 Villeurbanne, France

³ GeM - Institut de Recherche en Génie Civil et Mécanique, UMR CNRS 6183, Centrale Nantes, Nantes, 44321, France

⁴ CTIF – Centre Technique des Industries de la Fonderie, F-92318 Sèvres, France

⁵ Department of Mechanical Engineering, University of Ottawa, 161 Louis Pasteur, Ottawa, ON K1N 6N5, Canada

*Speaker: lucas.sanciet-munier@centralelille.fr

1. Introduction

Fatigue failure in metals can be largely dominated by the stage where small non-through fatigue cracks develop [1]. These cracks are characterized by an irregular geometry and a highly tridimensional mechanical behaviour [2].

Overloads (OL), *i.e.* a one-time increase in the maximum of a cyclic fatigue load, were shown to slow down or stop fatigue crack growth for a number of cycles [3]. Understanding these effects is of primary interest to mechanical design.

The experiment described here aims at quantitatively investigating OL effects on small non-through fatigue cracks with a method adapted to the 3D specificities of these objects using synchrotron tomography.

2. Materials and Methods

A cast aluminium-silicon alloy was specifically designed for two purposes: i) achieving a grain size small enough (around 125µm) for the microstructure in the small cross-section of tomography samples to be representative and ii) obtaining an even spread of small Si inclusions (1-10µm) to act as a speckle pattern for the use of digital volume correlation (DVC).

A fatigue sample was produced out of this alloy with a square cross-section of side 1.15mm. In its corner, a sharp rectangular notch (130x170µm) was made with a femtosecond laser in order to control the area of crack initiation.

The sample was subjected to uniaxial tensile fatigue loading at 20Hz in a machine mounted inside a synchrotron tomography setup for *in-situ* observation with phase contrast. The sample was scanned regularly throughout the experiment with a resolution of 0.65µm per voxel.

When crack propagation was deemed sufficient, an OL was applied to the sample. Fatigue loading was then resumed as it was prior to the OL. After the 100-1000 cycles of crack arrest/slowdown, and once the crack has resumed growing, the process of applying an OL and letting the crack grow again afterwards is repeated.

A total of 3 OL were performed on the sample, with decreasing amplitude each time in order not to exceed the plastic yield stress in the remaining ligament. Figure 1 shows a projection of the crack as it appears 10000 cycles after the first overload.

3. Results and Conclusion

From the reconstructed volumes, and using DVC, we plan to compute the strain state around the crack front, and expect to gain insight on its response to the OLs.

A measure of particular interest for crack growth problems is the stress intensity factor (SIF) which describes the stress state around the crack tip. We will work on producing profiles of this value along the crack front.

4. Acknowledgements

The authors wish to acknowledge Anne Bonnin, Goran Lovric and all the staff of the TOMCAT beamline at SLS.

5. References

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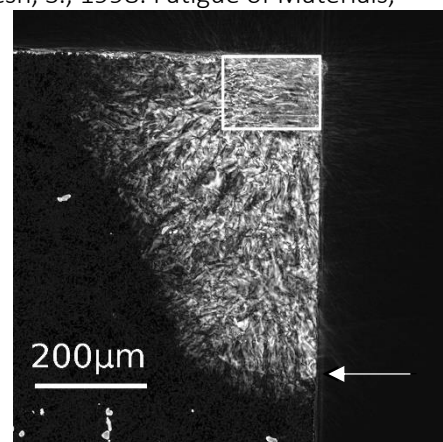


Figure 1. Projection of the crack at $N_{OL1}+10000$ cycles. The arrow indicates the position of the front at the OL which marks the boundary between pre-OL and post-OL crack growth. The square in the upper-right corner indicates the initial laser notch.