INDUSTRIAL PILOT PROJECTS

3D analysis of fatigue cracks in cast irons using in-situ x-ray synchrotron tomography

THE INDUSTRIAL CHALLENGE

Trucks and buses from Scania CV AB have several cast iron parts exposed to cyclic loads. These cyclic loads may lead to fatigue damage. A significant factor in damage development for cast iron components is crack propagation and this very often controls the total life of a component. A deeper understanding of the relation between the different microstructural constituents and the propagation of cracks would enhance material development efforts, as well as the ability to design and cast components with improved fatigue properties

WHY USING A LARGE SCALE FACILITY

Synchrotron experiments at a large scale facility are necessary to achieve sufficiently high spatial and temporal resolution to study the cracking during a fatigue load cycle.

HOW THE WORK WAS DONE

Cracks were initiated using a resonant fatigue test machine in the laboratory of RISE. The test samples were imaged by x-ray tomography at the 4D Imaging Lab at Lund University both prior and subsequent to the crack initiation. The tomograph images show the microstructure and defects, including shrinkage porosities, as well as the initiated fatigue crack.

Synchrotron experiments were performed at the Swedish beamline, P21, at the German synchrotron Petra III (DESY) in Hamburg. These experiments focused on tomography imaging of fatigue crack evolution and the microstructure of cast iron under mechanical load. The samples were imaged while subjected to stepwise loading, according to the fatigue load cycle, to study the opening and closure of the fatigue crack. In addition, stepwise loading at load levels exceeding the fatigue load cycle was applied to further grow the crack. Around 150 tomography images were produced to follow the crack growth. Johan Hector at P21 is greatly acknowledged for his assistance during the experiment.

Digital Volume Correlation (DVC) analyses were performed on the tomograph image sequences, which yields the strain distribution within the loaded samples and the possibility to assess the damage and deformation that takes place, e.g., in relation to graphite particles, pores and other defects.

THE RESULTS AND EXPECTED IMPACT

The analysis of the produced data shows that it is possible to observe damage and deformation mechanisms taking place at different microstructural features like graphite particles, porosities and carbides. These findings would not be possible to observe without 3D synchrotron imaging and in-situ loading. This will deepen the understanding and contribute to the development of materials with improved fatigue properties.

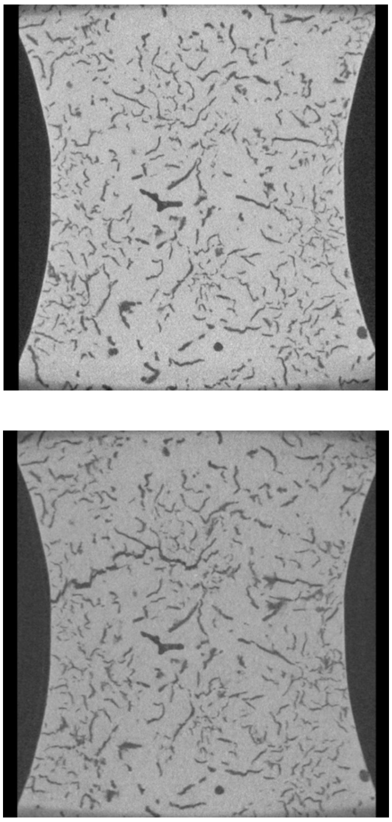

Figure. 2D slices extracted from the 3D tomography Images of the same sample with (lower) and without (upper) an initiated fatigue crack.

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