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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Approach for investigations of progressive fatigue damage in 3D in fibre composites using X-ray tomography

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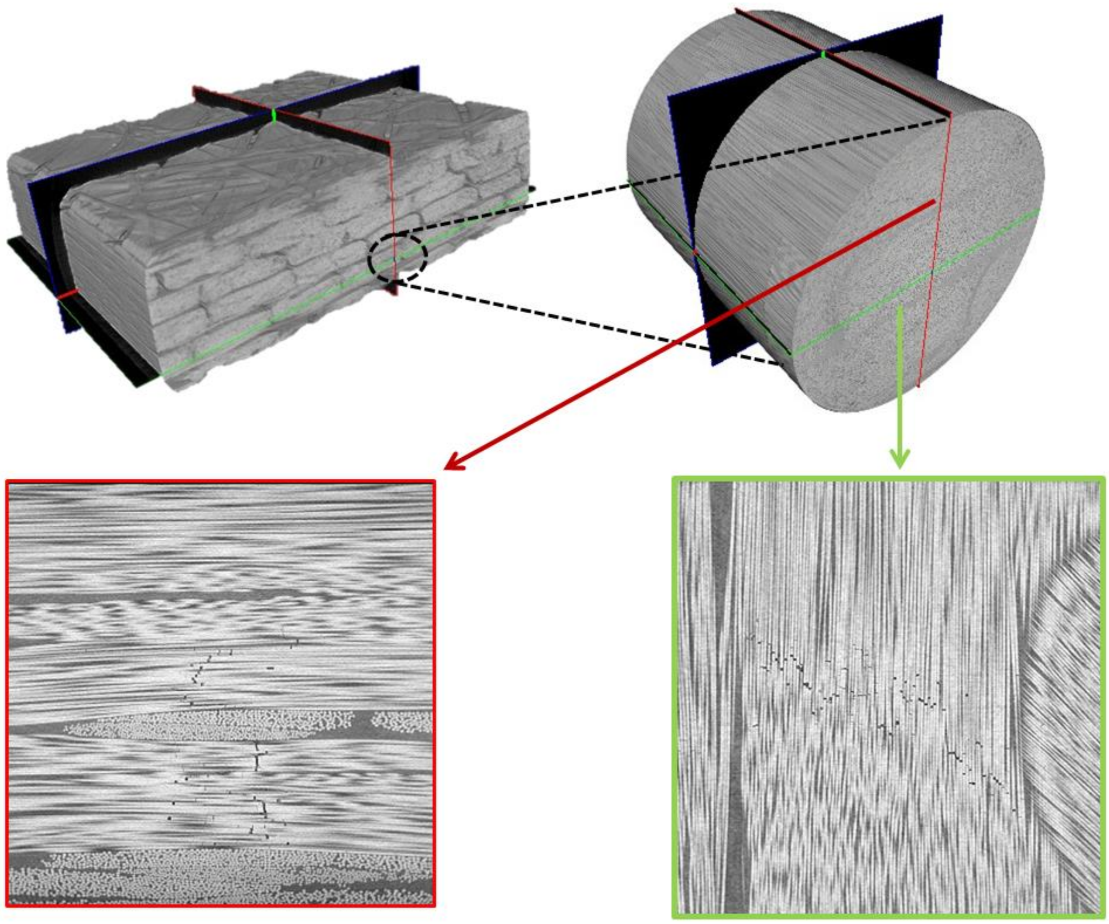
Lars P. Mikkelsen, M.Sc., M.E., PhD in Solid Mechanics, Associate Professor and team leader for Modelling in Composite and Material Mechanics. Research in fatigue and compression behaviour of composite materials and x-ray tomography based characterisation.

Kristine M. Jespersen, M.Sc., M.E., in Solid Mechanics. PhD student in the field of fatigue damage evaluation in composite materials with focus on the load carrying laminates in wind turbine blades using ex-situ x-ray tomography and in-situ transverse crack detection.

Abstract

Understanding fatigue damage initiation and evolution in the load carrying laminates inside wind turbine blade plays a key factor designing longer and lighter turbine blades. Thereby, it is possible to lower the Cost of Energy for the wind energy based electricity production either by simply building larger wind turbines or by upgrading existing turbines for lower wind classes' . In the presented work, a Zeiss Xradia Versa 520 scanner has been used in connection with ex-situ fatigue testing with the purpose of identifying fibre failure during the fatigue loading. The load carrying laminates is typically based on stacking of a number of non-crimp fabrics in where the load carrying fibres are oriented in the axial direction of the wind turbine blade. In order to ease the handling of the fabric during the dry fabric layup and ensure a good alignment of the final laminates, approximately 10% of the fibres are oriented in secondary directions. Thereby, the non-crimp fabric is given some shear stiffness.

The figures below show the results from a scanning of a fatigue damaged material. The width of the full scanned cross section is 15 mm, while the size of the zoomed scan is approximately 2.5 mm. The small black points visible in the two lower slices taken from the zoomed scan indicate fibre failure. From the red slice, the fibre failure is seen to be located in regions with the backing bundles are located. The backing bundles in the red slice are pointing out of the figure plan. In the green slice, it can be seen that the fibre failure in the load carrying fibres, are following the 45 degree orientation of the backing bundles where the 45 degree backing bundle can be seen at the left side of the green slice figure. In addition, to the scan case shown here, an ex-situ study of the fibre progression (Jespersen & Mikkelsen, 2016) has been performed. An ex-situ study where it has been important to design a good gripping strategy inside the scanning machine. Doing this, it has been possible to scan the same region multiple times. Thereby, a progressive fatigue damage evolution has been observed.



References

Jespersen, K. M., & Mikkelsen, L. P. (2016). Fatigue damage observed non-destructively in fibre composite coupon test specimens by X-ray CT. *IOP Conference Series: Materials Science and Engineering*, *139*, 012024. http://doi.org/10.1088/1757-899X/139/1/012024