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X-ray Computer Tomography-aided Engineering Process Data Collection of Non-crimp Fabric Reinforced Composites

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Abstract

This data in brief article describes a dataset used for an X-ray computer tomography aided engineering process consisting of X-ray computer tomography data and finite element models of non-crimp fabric glass fibre reinforced composites. Additional scanning electron microscope images are provided for the validation of the fibre volume fraction[1-15].The specimens consist of 4 layers of unidirectional bundles each supported by off-axis backing bundles with an average orientation on ±80° The finite element models, which were created solely on the image data, simulate the tensile stiffness of the samples. The data can be used as a benchmark dataset to apply different segmentation algorithms on the X-ray computer tomography data. It can be further used to run the models using different finite element solvers.

The presented data consists of three reconstructed X-ray computer tomography scans of non-crimp fabric reinforced glass fibre composites The scans were taken with Zeiss Xradia 520 Versa at DTU Roskilde, Denmark. The image data for all three scans is saved and uploaded as .nil-file. Each scan consists of three single scans that were stitched together in order to increase the field of view. For the acquisition a detector with 2000 × 2000 pixel was used. Different settings for the accelerating voltage, power, exposure time, number of projections and binning were chosen. A full rotation of the sample was performed and the optical magnification as well as the distance sample to source and sample to detector was kept constant. Further details can be found in . For each scan a .pdf-file with settings from the scanner is uploaded.

Introduction

Additionally, scanning electron microscope images are described. The novel segmentation approach for non-crimp reinforced composites in can be used to calculate the fibre volume fraction based on the fibre areal weight. To validate the accuracy of the determined fibre volume fraction of this new approach scanning electron microscope images were acquired using, therefore, the samples, which were first scanned by tomography, were cut in half. The cutting surface was polished and an approximately 10 nm thin layer of carbon was applied on the surface using a Bal-Tec SCD 005 Sputter Coater. The SEM images were acquired using a solid-state backscattered detector, an accelerating voltage of 20 kV and a magnification that resulted in a pixel size of 346.02 nm, 349.65 nm and 253.80 nm for sample A, E and G, respectively. The data is uploaded as .tif-files. In addition, a meta-file with acquisition details is attached..

Subjective Heading

The non-crimp reinforced glass fibre composite is laid up of four unidirectional bundles stitched together by a thread. Additionally, randomly placed overlapping backing bundles are supporting the structure. The backing bundles are orientated at approximately ±80° which results in a stacking sequence $[b/0,b/0]_s$ where "b" denotes a layer of backing bundles and "0" a layer of unidirectional bundles. The reader is referred to for a detailed description of how the samples were manufactured and to for a how the samples were milled.

Discussion

The scanning electron microscope images were processed with a Matlab script, where the data was loaded with the function imread and binarized with the function imbinarize. Therefore, the "adaptive" option was chosen. With the function imcrop single bundles can be cropped chosen, in order to focus only on the fibre volume fraction inside bundles. The function imhist returns the number of pixels of both components. Those were used to calculate the fibre volume fraction inside the fibre bundles.

The non-crimp reinforced glass fibre composite is laid up of four unidirectional bundles stitched together by a thread. Additionally, randomly placed overlapping backing bundles are supporting the structure. The backing bundles are orientated at approximately ±80° which results in a stacking sequence where "b" denotes a layer of backing bundles and "0" a layer of unidirectional bundles. The reader is referred to for a detailed description of how the samples were manufactured and to for a how the samples were milled.

With a pre-processed surface mesh of the fibre bundle, the matrix mesh surrounding the bundles could be generated. Therefore, a block of the size of the scanned data was created and applied with a 2D surface mesh. The fibre bundle elements that coincided with the matrix elements were projected onto the matrix surface and the nodes were pasted on each other. By this procedure a closed volume for the matrix surrounding the fibre bundles could be generated. In the end, penetration-free 3D solid meshes for both components (matrix and bundles) were obtained.

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The non-crimp reinforced glass fibre composite is laid up of four unidirectional bundles stitched together by a thread. Additionally, randomly placed overlapping backing bundles are supporting the structure. The backing bundles are orientated at approximately ±80° which results in a stacking sequence $[b/0,b/0]_s$ where "b" denotes a layer of backing bundles and "0" a layer of unidirectional bundles. The reader is referred to for a detailed description of how the samples were manufactured and to for a how the samples were milled.

The scanning electron microscope images were processed with a Matlab script, where the data was loaded with the function imread and binarized with the function imbinarize. Therefore, the "adaptive" option was chosen. With the function imcrop single bundles can be cropped chosen, in order to focus only on the fibre volume fraction inside bundles. The function imhist returns the number of pixels of both components. Those were used to calculate the fibre volume fraction inside the fibre bundles.

The mesh for all three models has been created based on the segmentation outcome described in This surface mesh, as segmentation outcome, most likely consists of a huge number of elements; around 5 million for this study. A reduction of this element number is crucial to obtain finally a reasonable number of solid elements. This reduction of the surface elements most likely leads to intersections and element quality issues e.g. high aspect ratios. Some experience is required for this process. A fully automated way would however suffer from larger inaccuracies in the surface representation. The average element size was set to 120 μm.

With a pre-processed surface mesh of the fibre bundle, the matrix mesh surrounding the bundles could be generated. Therefore, a block of the size of the scanned data was created and applied with a 2D surface mesh. The fibre bundle elements that coincided with the matrix elements were projected onto the matrix surface and the nodes were pasted on each other. By this procedure a closed volume for the matrix surrounding the fibre bundles could be generated. In the end, penetration-free 3D solid meshes for both components (matrix and bundles) were obtained.

In the mesh file all elements that belong to a fibre bundle are assigned with their material orientation with the Abaqus keywords . Further details about those keywords can be found in the Abaqus Keywords Reference Guide (Note: Not publicly available).

A linear orthotopic material model was defined. The parameters were calculated with a micro-mechanical model based on the fibre volume fraction inside the bundles. Further details about the material model can be found in The values in the material model are normalised with the single fibre stiffness used in the unidirectional bundles.

The presented data consists of three reconstructed X-ray computer tomography scans of non-crimp fabric reinforced glass fibre composites the scans were taken with Zeiss Xradia 520 Versa at DTU Roskilde, Denmark. The image data for all three scans is saved and uploaded as .nii-file. Each scan consists of three single scans that were stitched together in order to increase the field of view. For the acquisition a detector with 2000×2000 pixel was used. Different settings for the accelerating voltage, power, exposure time, number of projections and binning were chosen. A full rotation of the sample was performed and the optical magnification as well as the distance sample to source and sample to detector was kept constant. Further details can be found in For each scan a .pdf-file with settings from the scanner is uploaded.

Conclusion

This data in brief article describes a dataset used for an X-ray computer tomography aided engineering process consisting of X-ray computer tomography data and finite element models of non-crimp fabric glass fibre reinforced composites. Additional scanning electron microscope images are provided for the validation of the fibre volume fraction. The specimens consist of 4 layers of unidirectional bundles each supported by off-axis backing bundles with an average orientation on ±80° The finite element models, which were created solely on the image data,

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Conflict of Interest

The authors declare that they are no conflict of interest**.**

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