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Working

Serial killer pore investigation: protocol for analyzing fatigue failure pores in additively manufactured Ti6Al4V

Muofhe Tshibalanganda[1], Anton du Plessis[1], Stephan le Roux[1]

[1]CT scanner facility

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Muofhe Tshibalanganda
CT scanner facility

ABSTRACT

This protocol outlines the steps followed to determine a potential "killer pore" in the area of failure of DMLS Ti6Al4V specimen.

The methodology can be used more generally for positively identifying and quantifying small isolated pores in additively manufactured metals. In this case the focus was on analysis of a 4 mm region near the eventual fracture surface, to identify all pores in the vicinity of the "killer pore" - the one causing failure by fatigue tests. This protocol was developed for Ti6Al4V with 99.99% density (only small amount of porosity, very small pores only), tensile fatigue specimen round dogbone geometry with 5 mm gauge width.

PROTOCOL STATUS

Working

We use this protocol in our group and it is working

GUIDELINES

The samples are scanned before fatigue testing.

SAFETY WARNINGS

BEFORE STARTING

Make sure to scan with the sample number facing up to know which side is up during analysis.

Before Scanning

1 Wrap the sample inside a bubble wrap for support. Make sure the marked threaded grip is facing up.This is to know which side is up when analysing.

Sample mounting

2 Load the sample on a foam (e.g. florist oasis).

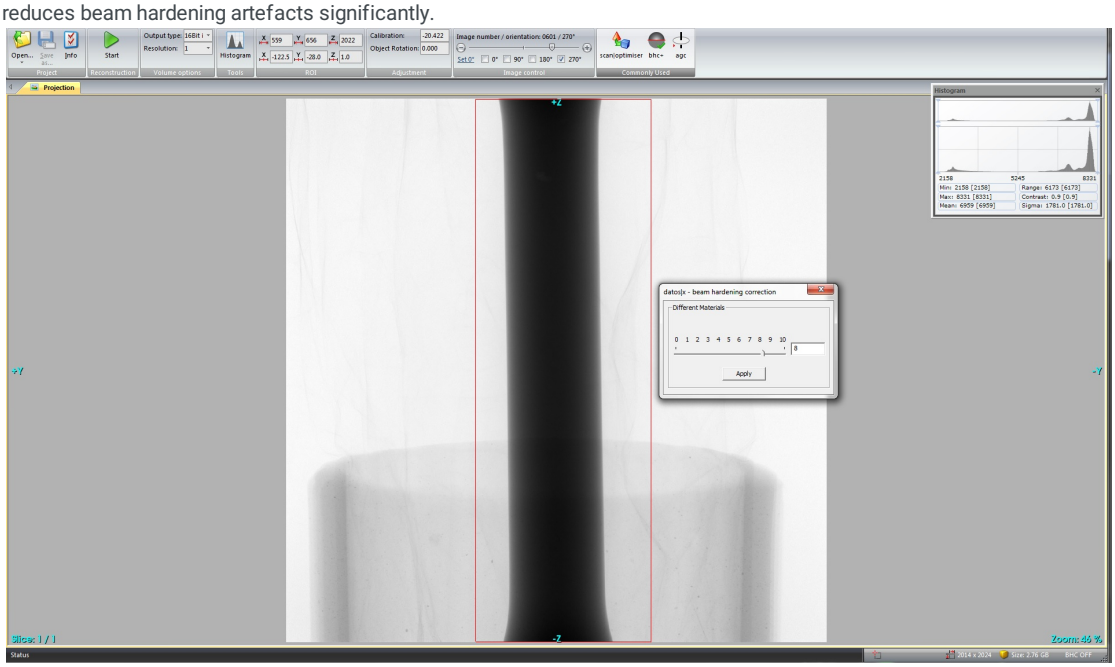
Scanning Stettings

3 The sample was scanned using the scanned using Phoenix V|Tome|X L240 (General Electric Sensing and Inspection Technologies Phoenix X-ray, Wunstorff, Germany) microCT system.

Voltage	160kV
Current	100 µA
X-ray Sensitivity	4
Voxel size	15 µm
Timing	333 m/s
Images	800
Averaging	2
Skip	1

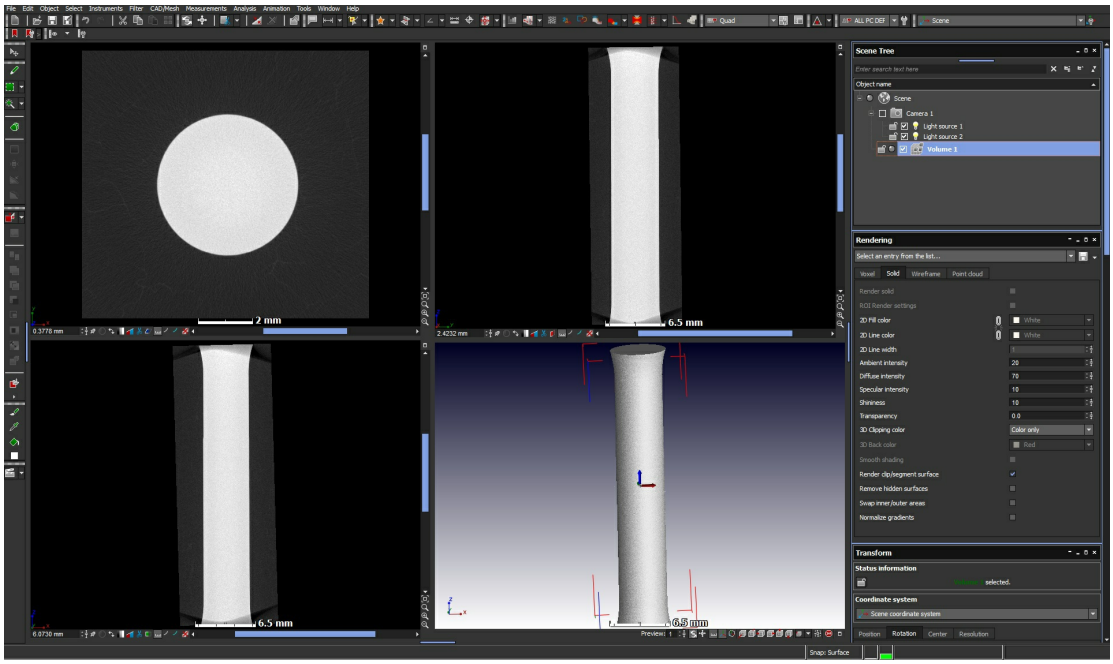
Recontruction

4 Reconstruction of the 3D data is done using General Electric Datos 2.2, using specifically beam hardening correction value of 8 - this reduces beam hardening artefacts significantly.

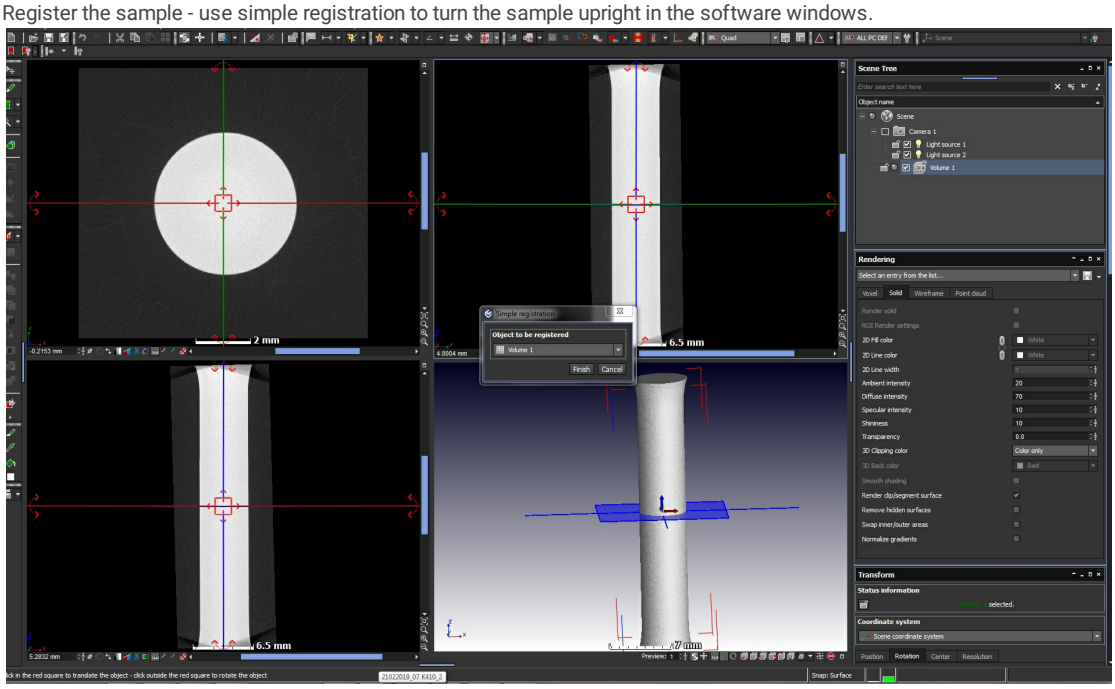


Porosity analysis

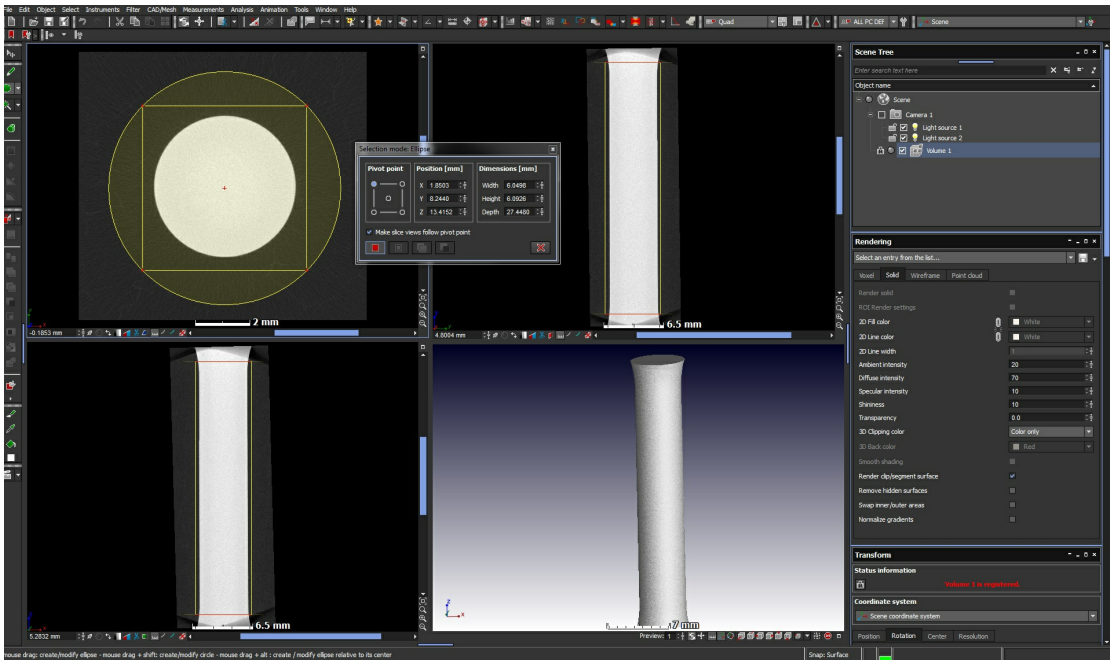
5 Analysis of 3D data is described here using Volume Graphics VGSTUDIO MAX 3.2 .



6 Register the sample - use simple registration to turn the sample upright in the software windows.

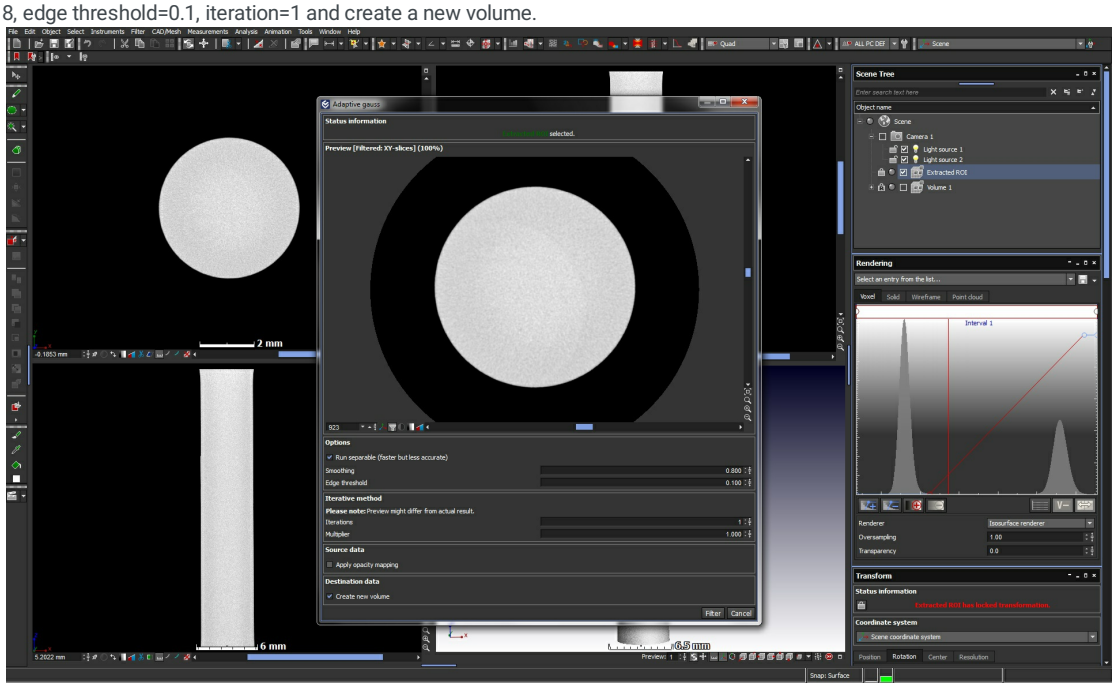


7 Use the ellipse Region of interest to crop the sample excluding the area with the cone beam artefact.

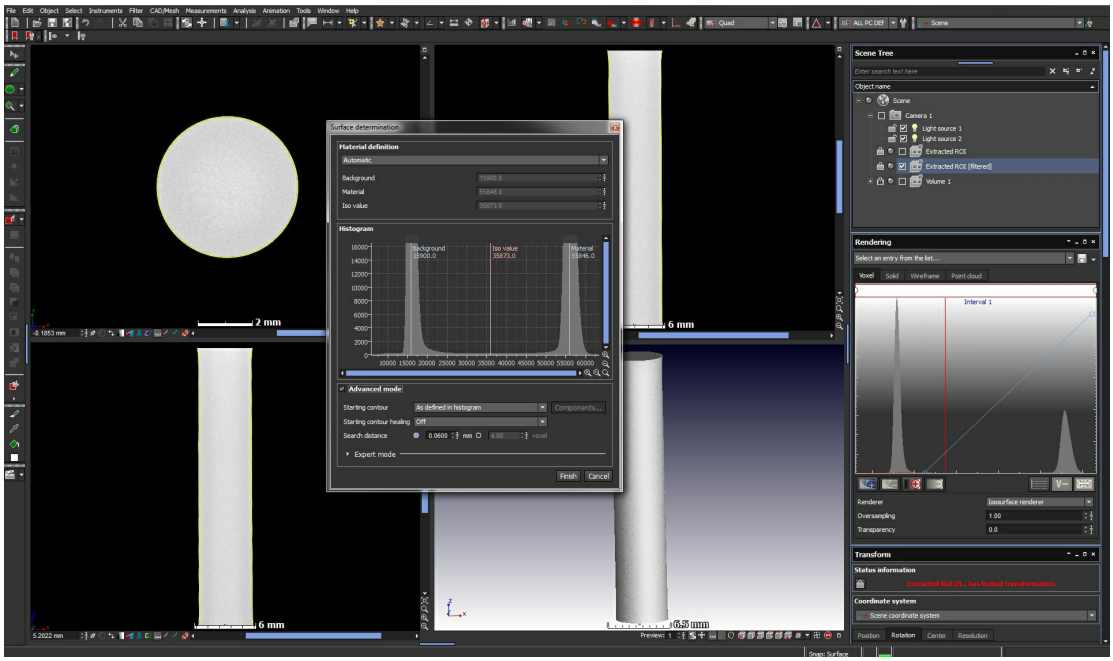


8 Extract the region of interest to create new volume.

9 De-noising is done using the filters Adaptive Gauss with smoothing factor 0.
8, edge threshold=0.1, iteration=1 and create a new volume.

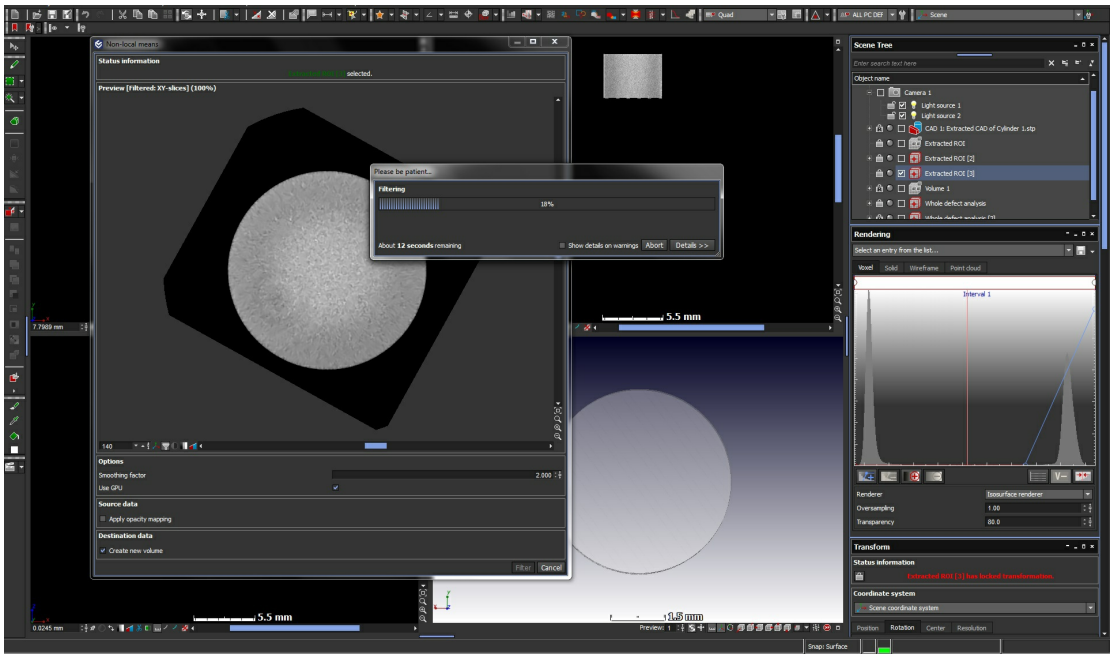


10 Define the material by using the automatic and advanced mode surface determination.



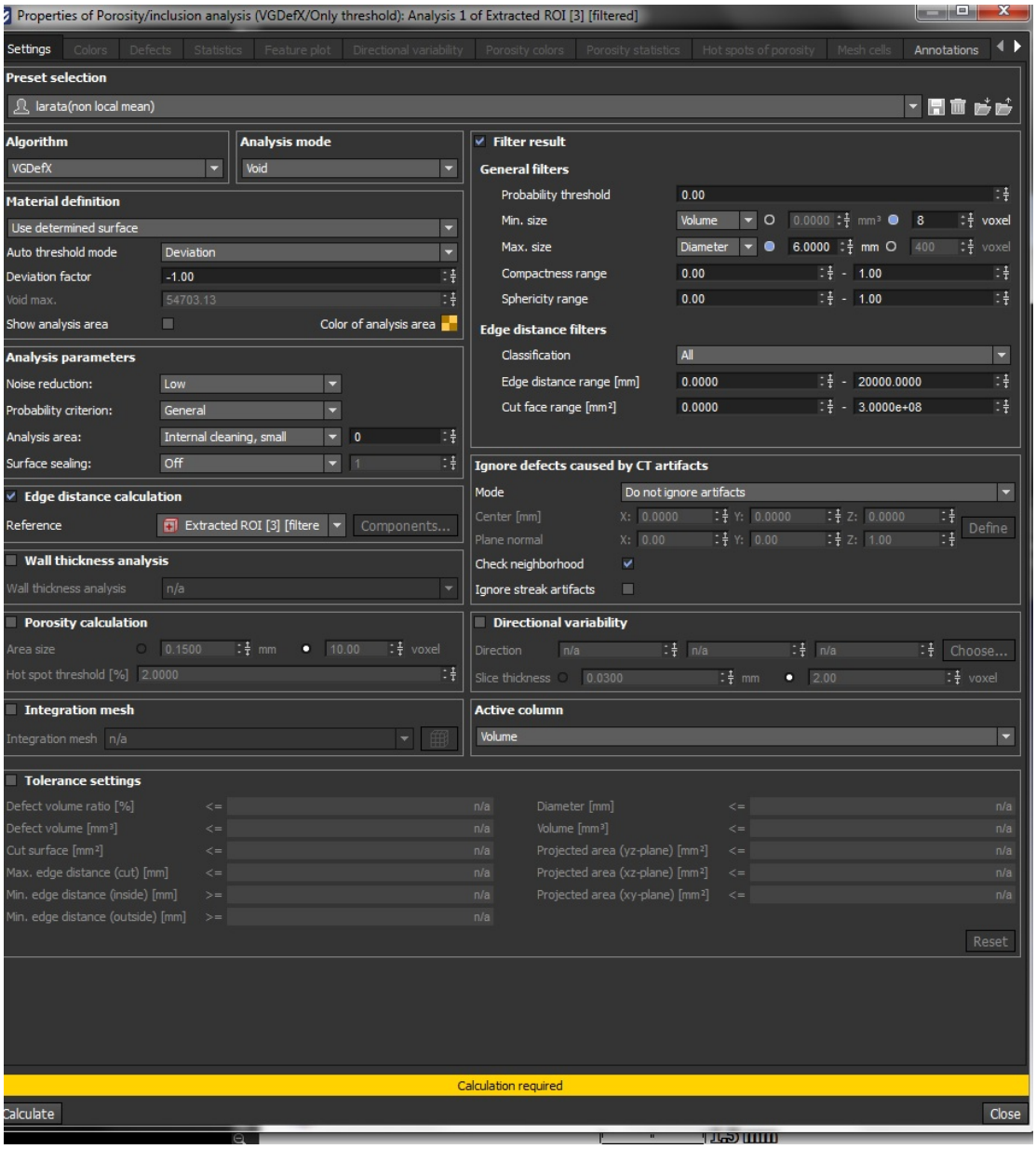
11 In the area of failure crop out 4 mm

12 Denoise using the non local mean filter using the smothing factor 2

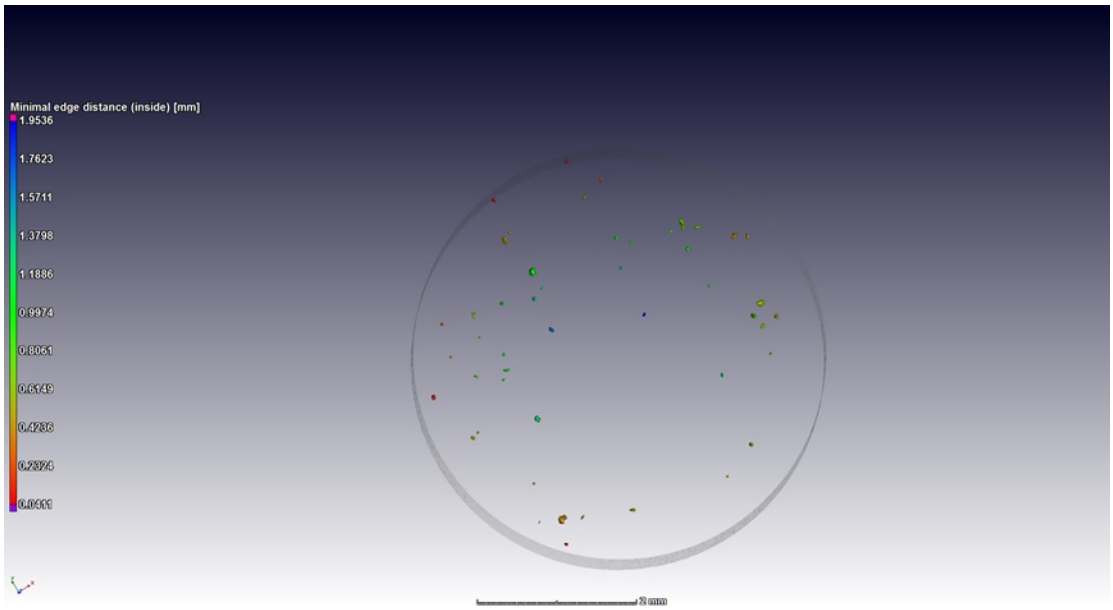


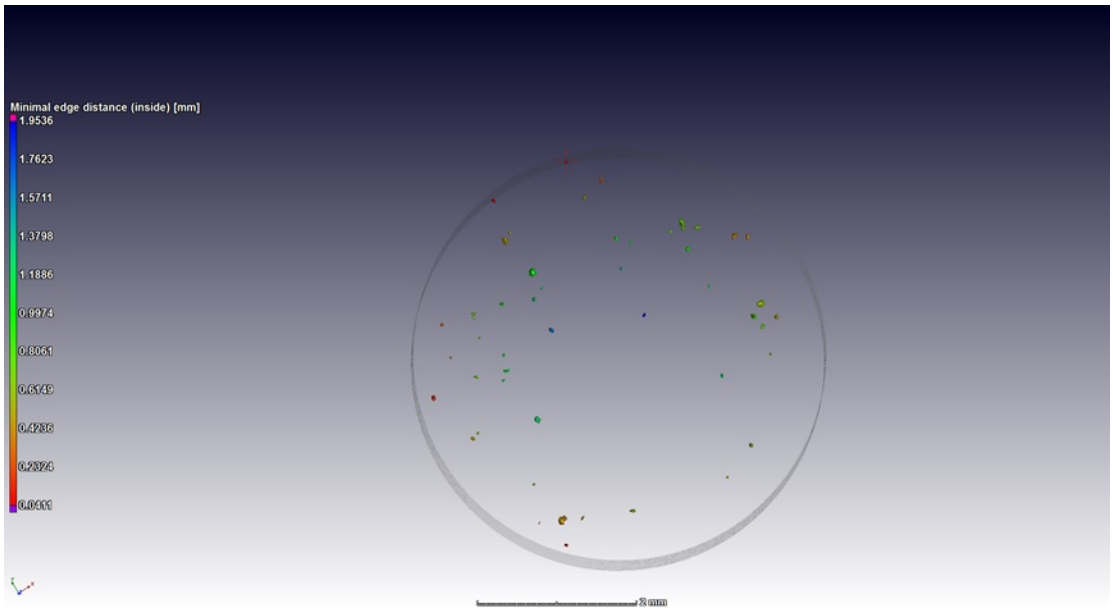
13 Define the material by usinng surface determination. Use the automatic and advanced mode.

14 Perfom the poroity analysis using
Probability 0
minimum voxel 8
Maximum voxel 400
Auto threshold deviation
Deviation factor
Select the edge distance calculation



15 Sort by minimum edge distance to clearly define the potential crack intiating pores closest to the surface.





3D rotation video_1.wmv

3D rotation video_2.wmv

16 Save the defect analysis as csv file.

17 The data is saved including the filtered data set, as a image stack (tiff). These can be viewed manually without special software. The analyzed volume can be opened in free myVGL software.