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X-ray Computed Microtomography for the Inspection of Flexible Risers

A. J. P. Moreira[1], O. M. O. Araújo[1], A. S. Machado[1], R. T. Lopes[1], and D. F. Oliveira[1]

adrianajpmoreira@coppe.ufrj.br, Nuclear Instrumentation Laboratory/PEN/COPPE/UFRJ, Brazil

INTRODUCTION

Flexible risers are vital components in oil transportation, connecting wells to platforms, but face challenges such as corrosion caused by trace gases such as CO2 and H2S, leading to material loss and microcracks. These structures endure intense pressure and mechanics during operation, requiring continuous monitoring and maintenance. Comprising polymeric and metallic layers, they are designed for interaction to meet field requirements. Failures generally result from tensile armor wire breaking, initiating cracks, and structural fragility, demanding constant monitoring for safety. Non-destructive testing techniques, such as microCT, offer non-invasive inspection, and can be crucial for early detection and prevention of irreparable damage.

METHODOLOGY

- For this study, a 440 mm section of a flexible riser, with dimensions of 155 mm in external diameter, was scanned using a Phoenix V|tome|x M microtomography system. This system features integrated control for X-rays, detector, and sample manipulation, ensuring high-quality image scans.
- Operating with a high-power microfocus tube, with a voltage of up to 300 kV at a maximum power of 500 W, and a stable digital detector, GE PXR250RT, with a pixel size of 200 µm and 2024 x 2024 pixel matrix.
- The riser section was rotated 360 degrees within the system, with acquisition parameters optimized as shown in Table I. Following the acquisition, the images were reconstructed and analyzed using appropriate software.

Table I: Acquisition Settings

Microtomography System	Phoenix V|tome|x M
Voltage (kV)	260
Current (µA)	340
Acquisition Time (ms)	500
Projections	1200
Effective Pixel Size (µm)	114
System Rotation	360°

RESULTS AND DISCUSSION

The 3D images obtained by microCT show the metallic layers of the riser, where defects are evident in their innermost layer – interlocked carcass –, the smallest being on the order of 0.268 mm. Figure 1 shows the interlocked carcass with defects measured and shows the pressure armor layer.

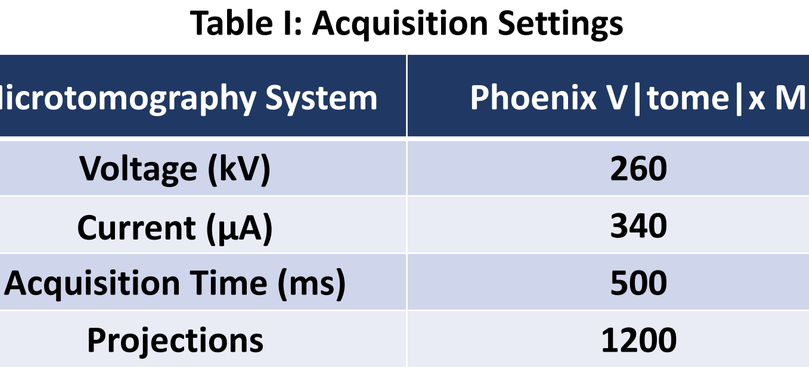

Figure 1: MicroCT slice – defects in the internal layer and the pressure armor layer

In Figure 2, the 3D image obtained by the microCT process shows all the structural layers that make up the riser – from the external to the internal part, it is noted: the interlocked carcass, the pressure armor layer, and the internal and external tensile armor layers.

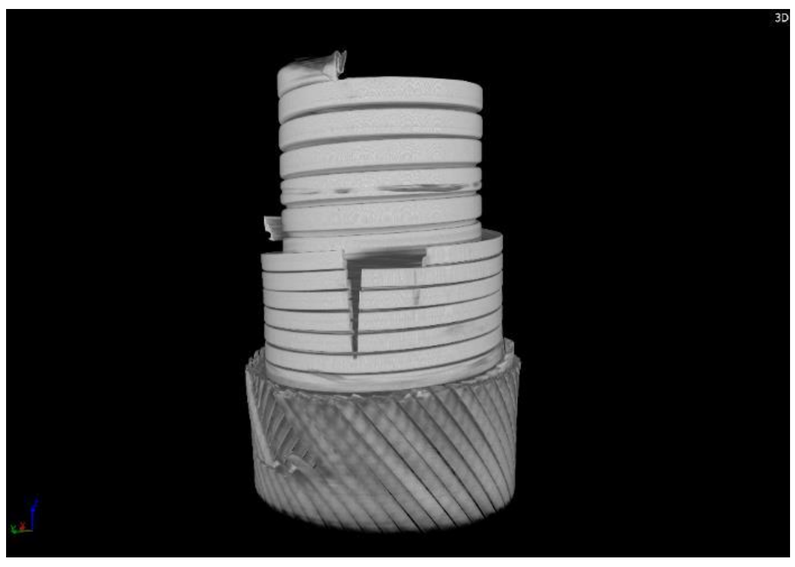

Figure 2: MicroCT Image - 3D model of the flexible riser layers

The image segmentation process was applied to identify each riser layer separately. During the analysis, defects were identified in all layers of the riser. In Figure 3 and Figure 4, defects can be visualized and measured on a color scale in a range up to 2 mm.

Figure 3: MicroCT Image - segmentation process, visualization of defects in the metal layers, and defect extraction - longitudinal view

Figure 4: MicroCT Image - visualization and extraction of defects - axial view

CONCLUSION

X-ray Computed Microtomography proves to be a promising approach for inspecting the metallic layers of flexible risers. Through image segmentation, different layers were identified and analyzed separately. Defects were found in all layers, with the smallest in the interlocked carcass, measuring about 0.268 mm. MicroCT images produced satisfactory results, demonstrating the technique's effectiveness in non-destructive inspection for defect detection.

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