POD Study: Can *in situ* monitoring replace CT scanning?

Detecting porosity in Laser Powder Bed Fusion (L-PBF) parts is critical, as internal flaws can lead to in-service failure. Traditional post-production inspection with X-ray CT scanning is expensive and time-consuming, creating significant production bottlenecks. A direct comparison between X-ray CT and AMiRIS in situ data with POD $a_{90/95}$ of 82.3µm unlocks the transition from 100% CT inspection to occasional CT auditing.

Experiment

The Build: 20 coupons built from 316L on Sisma Mysint 300 and inspected in real-time using AMiRIS. Coupons contained intentional voids from 50-500µm and process induced defects.

Testing: Post build, the coupons were removed and scanned on a Zeiss Xradia Versa 515 microfocus X-ray CT with a voxel size of 20.55µm.

CT Data: X-ray CT TIFF slices were imported into AMiRIS platform, aligned, and CT pores were identified via automatic segmentation. A total of 2534 pores were detected by CT.

Probability of Detection: Logistic regression using Maximum likelihood estimation (MLE) with statsmodels Python package and calculations as per ASTM E2862-23. The size of the flaw recorded in CT was used as the ground truth.

Analysis: AMiRIS™ identifies porosity by analysing localised thermal variances across successive layers, allowing it to confidently track a defect as it forms and distinguish it from single-layer process noise. This provides a reliable, layer-by-layer understanding of part quality.
The AMiRIS detected porosity is directly compared to the detected CT pores and visualised in 3D.

POD Results: Probability of detection a_{90} of 73.4µm and $a_{90/95}$ 82.3µm. False Call rate of 7.01% with 95% confidence. The largest missed flaw was 126µm from 2534 total defects in the dataset.

Outcome: Where the critical flaw size is greater than 82µm, CT scanning is only required as a periodic audit to validate in situ findings. Parts where pores are larger than the critical flaw size are scrapped, removing the need for CT inspection of known failed parts.

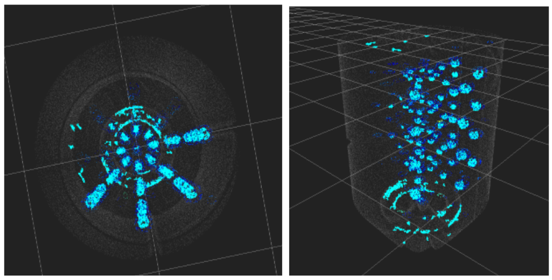


Fig 1. AMiRIS Porosity (dark blue) and CT (light blue) overlaid together in their 3D context

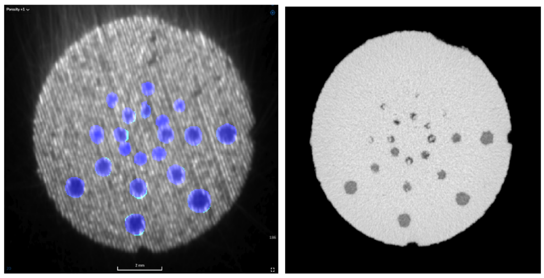


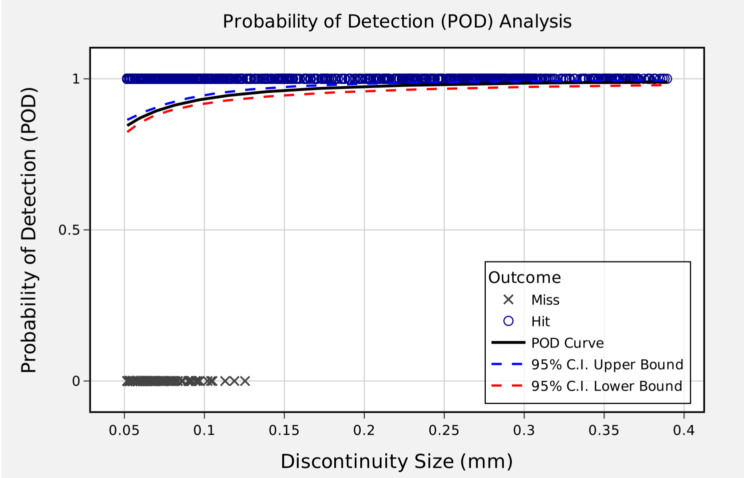
Fig 2. Porosity (left, dark blue) directly identified in process corresponding to pores identified in CT (right)

Benefits

1 **Building Trust:** Industry standard approaches such as POD studies aid in qualification in situ data as a true NDT method. When coupled with mechanical data, robust estimations of part mechanical properties and lifespan can be made - building trust in metal AM parts.

2 **CT Scan Augmentation/Reduction:** AMiRIS detects porosity at a resolution potentially exceeding standard CT capabilities. While CT detects consolidated defects post-build, AMiRIS observes them in situ. Direct comparison between AMiRIS data and imported CT data allows for correlation studies, reducing the reliance on extensive CT scanning for production parts.

3 **Part Certification Support:** Provides layer-wise documentation of build quality. Automatic reporting and data traceability can assist in the rigorous certification requirements common in industries like aerospace, reducing the iterative cycles between manufacturing and inspection.



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