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COMPRESSIVE RESPONSE ANALYSIS OF HOLLOW STRUT LATTICE STRUCTURES VIA 4D X-RAY CT

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Introduction

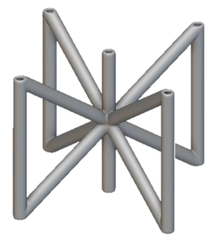
AM for hollow strut lattice structures

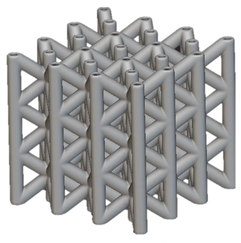
- AM enables precise and efficient creation of complex geometrical parts based on sliced 3D models.
- Focus: manufacturing of **hollow strut lattice structures**.
- Inherently, hollow struts show a **higher second moment of inertia (*I*)**, resulting in increased resistance to bending.

$I = \pi\left(d_{outer}^4 - d_{inner}^4\right)/64 \quad > \quad I = \pi\left(d_{outer}^4\right)/64$

Specimen design and manufacturing

- **L-PBF** manufactured 4 specimens.
- Used material: **AlSi10Mg**
- Innovative lattice structure design. **BCCZ + central vertical strut in nodes**.





- 3x3 cell structure dimensions: 26 x 26 x 25 mm

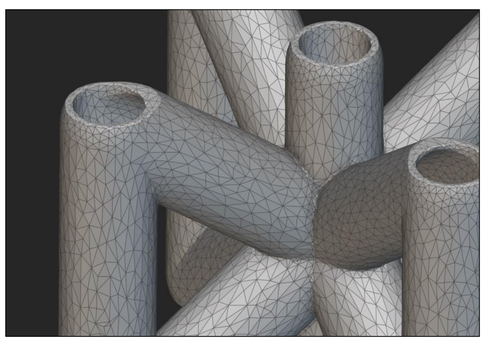
Strut geometry of each specimen: $\varnothing_{ext} = 2.2$ mm / t = wall-thickness

t = 0.3 mm | t = 0.5 mm | t = 0.6 mm | No hole

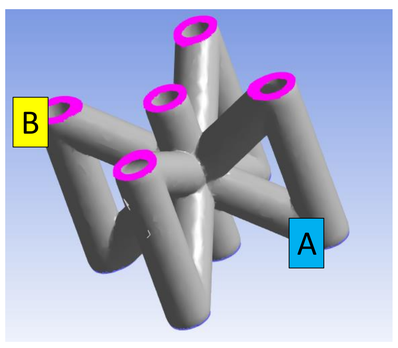
FEM Simulation

- ***"nTopology"*** software was used to generate the structure and the mesh.
- Mesh characteristics:
  - Min. feature size: 0.05 mm
  - Obj. edge length: 0.5 mm
  - Geometric order: Quadratic
  - Type of element: Tetrahedral

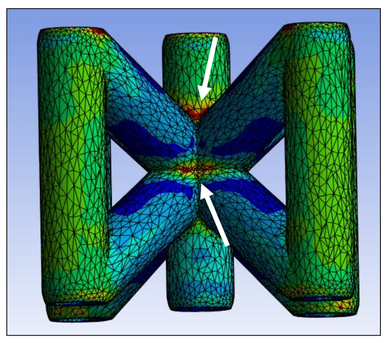
Mesh



Model



- Boundary conditions:
  - A: Fixed support on faces
  - B: Nodal displacement (0.01 mm)

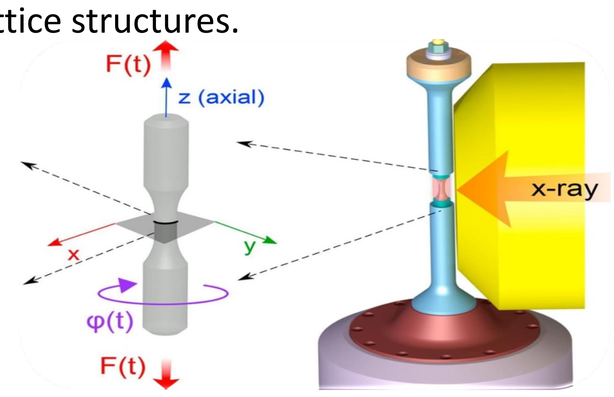


- ***"ANSYS"*** software was used to simulate the process.
- Static structural analysis simulation.
- Stress concentration in nodes.

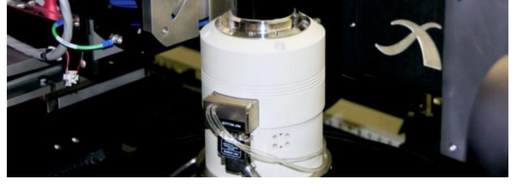
FEM Model validation

4D X-Ray Computed Tomography

- Test characterization via **XCT**, providing non-destructive micron-scale reconstruction of both internal and external characteristics.
- Introduction of the time (*t*) variable to the scans. Enabling **real-time XCT** monitoring of dynamic phenomena.
- **4D XCT + compression testing** = Possibility to observe processes such as crack propagation, influence of weak points or shear banding in lattice structures.

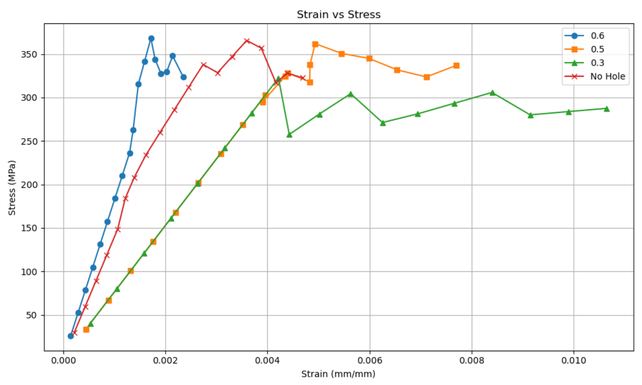


- XCT scan via **RX Solutions EasyTom XL** equipment. Micro/nano CT system.
- Compression tests carried out using **DEBEN CT5000RT 5KN** loadcell.
- Quasi-static analysis.



FEM Results

- **Hole size influence** on stress-strain behavior.
- First stress peak value does not decrease according to cross-sectional area reduction.



Conclusions and future work

- It is anticipated that the **strength** of specimens with holes **will not decrease proportionally** to reduced cross-sectional area.
- **Future work** will involve **4D XCT** to precisely identify where the **weak points** are and where **failure** initiates.
- It is expected to also test the influence of the central column.

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