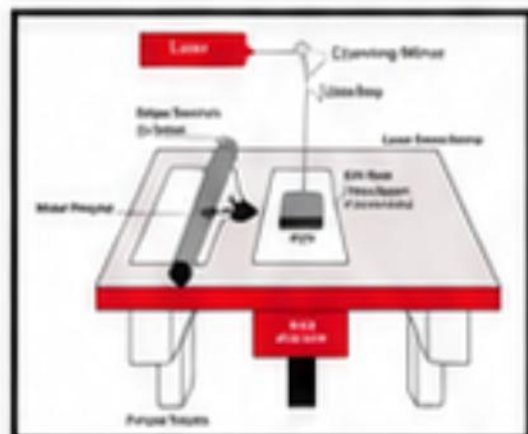


Background

Laser Powder Bed Fusion (LPBF)



- Metal 3d printing
- Allows for the manufacturing of complex geometries with broad range of materials
- Use of powders to build part layer by layer
- Important Parameters:
 - Laser Power
 - Scan Speed
 - Hatch Spacing
 - Layer Thickness



Chowdhury et al.

Experimental Questions & Approach

Does VED reliably predicts relative density when the same VED value is produced with different parameter combinations in 316L stainless steel and Ni-based super alloys?

- Design of Experiment (DOE) 1
 - 316L Stainless Steel
 - Varying Power and Scan Speed
- DOE 2
 - 316L Stainless Steel
 - Varying Power and Hatch Spacing
- DOE 3
 - Inconel 718
 - Varying Power and Scan Speed
- DOE 4
 - Inconel 718
 - Varying Power and Hatch Spacing

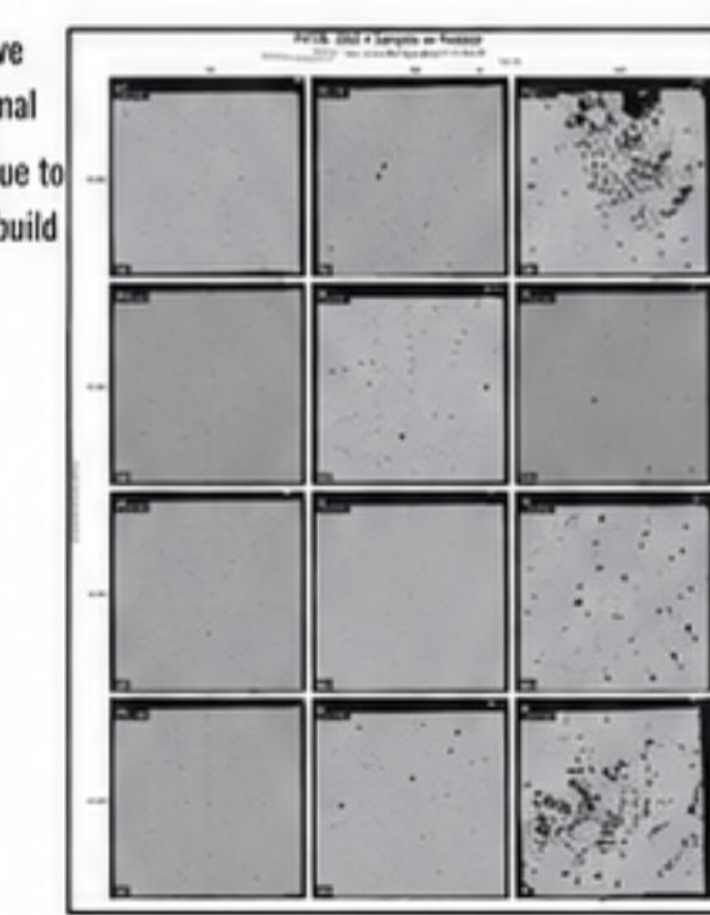
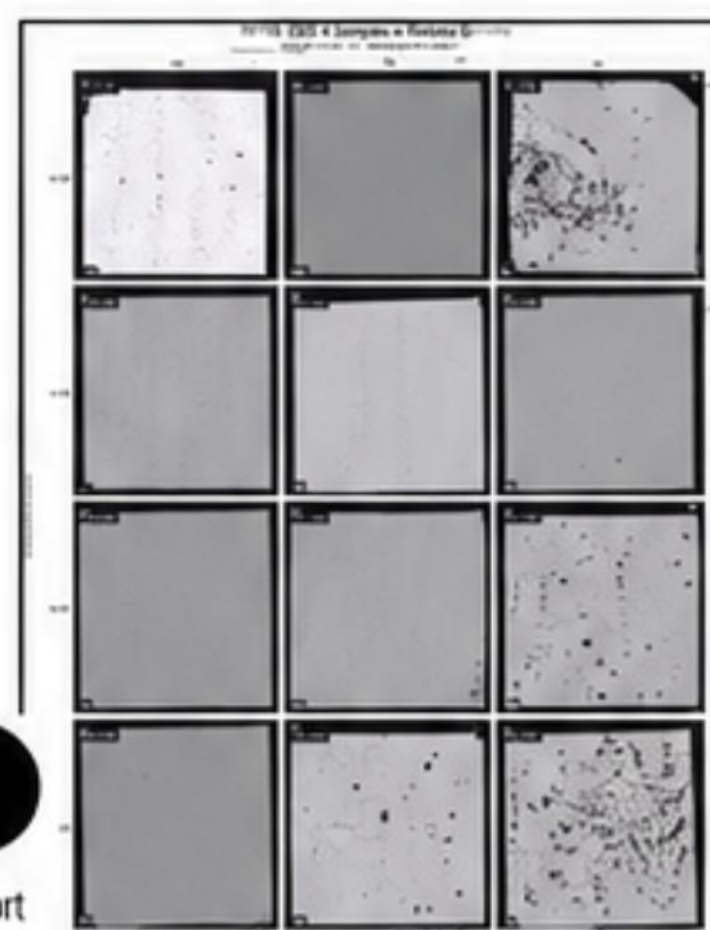
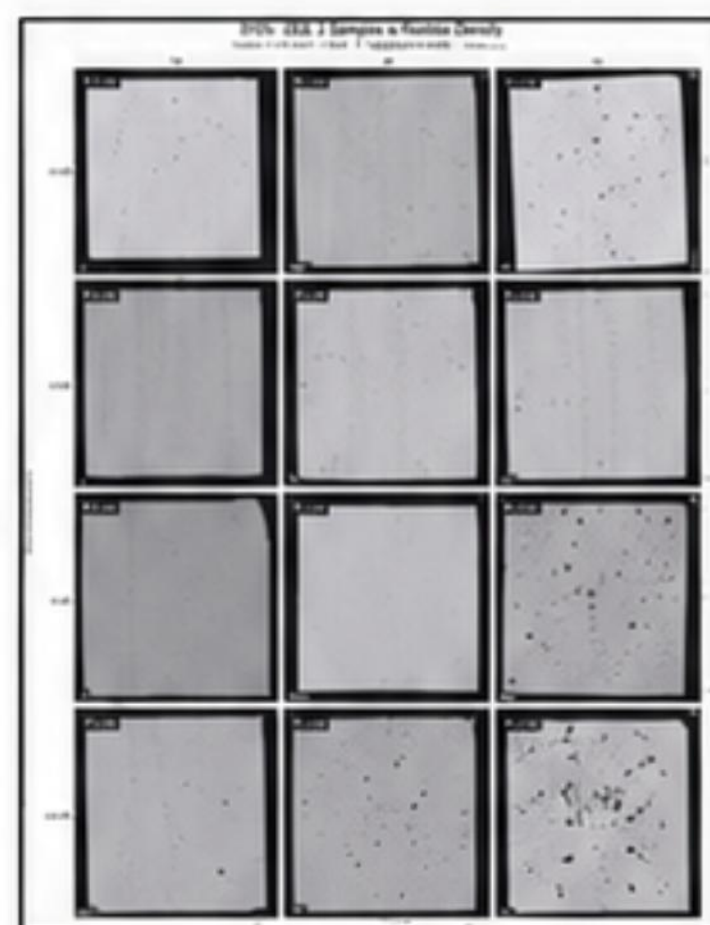
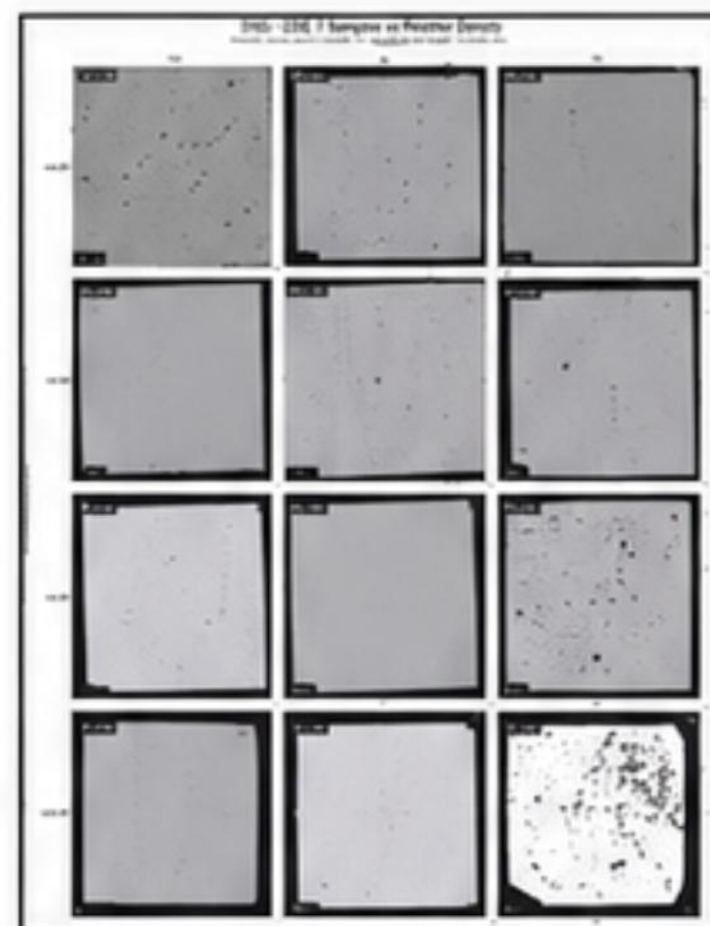
Definitions

- Volumetric Energy Density (VED)
- Alloy/Superalloy
- Porosity
- Relative Density (RD)

$$VED = \frac{P}{v \cdot h \cdot t} \cdot \left[\frac{J}{mm^3} \right]$$

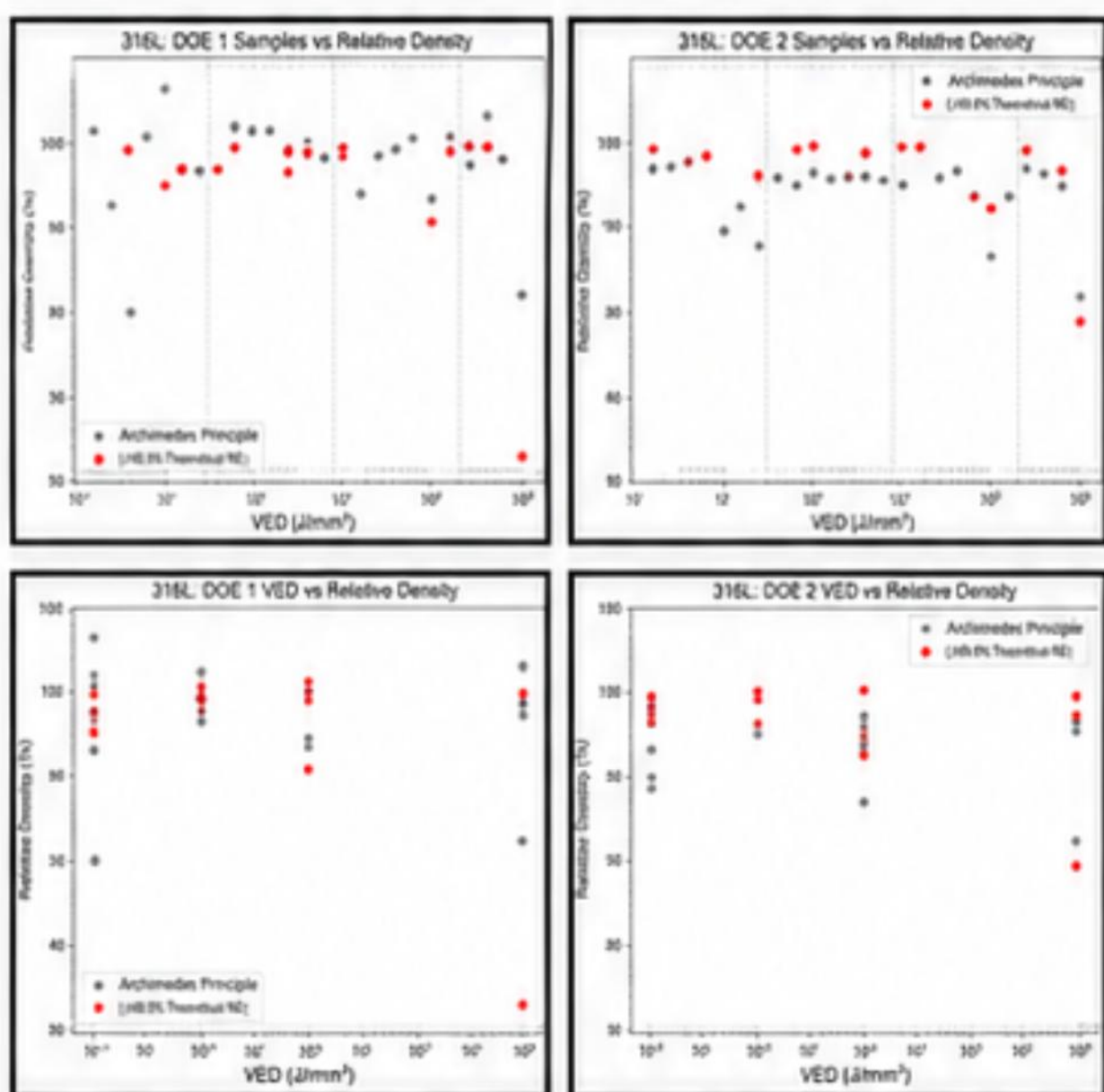


Higher VED
increases energy
input



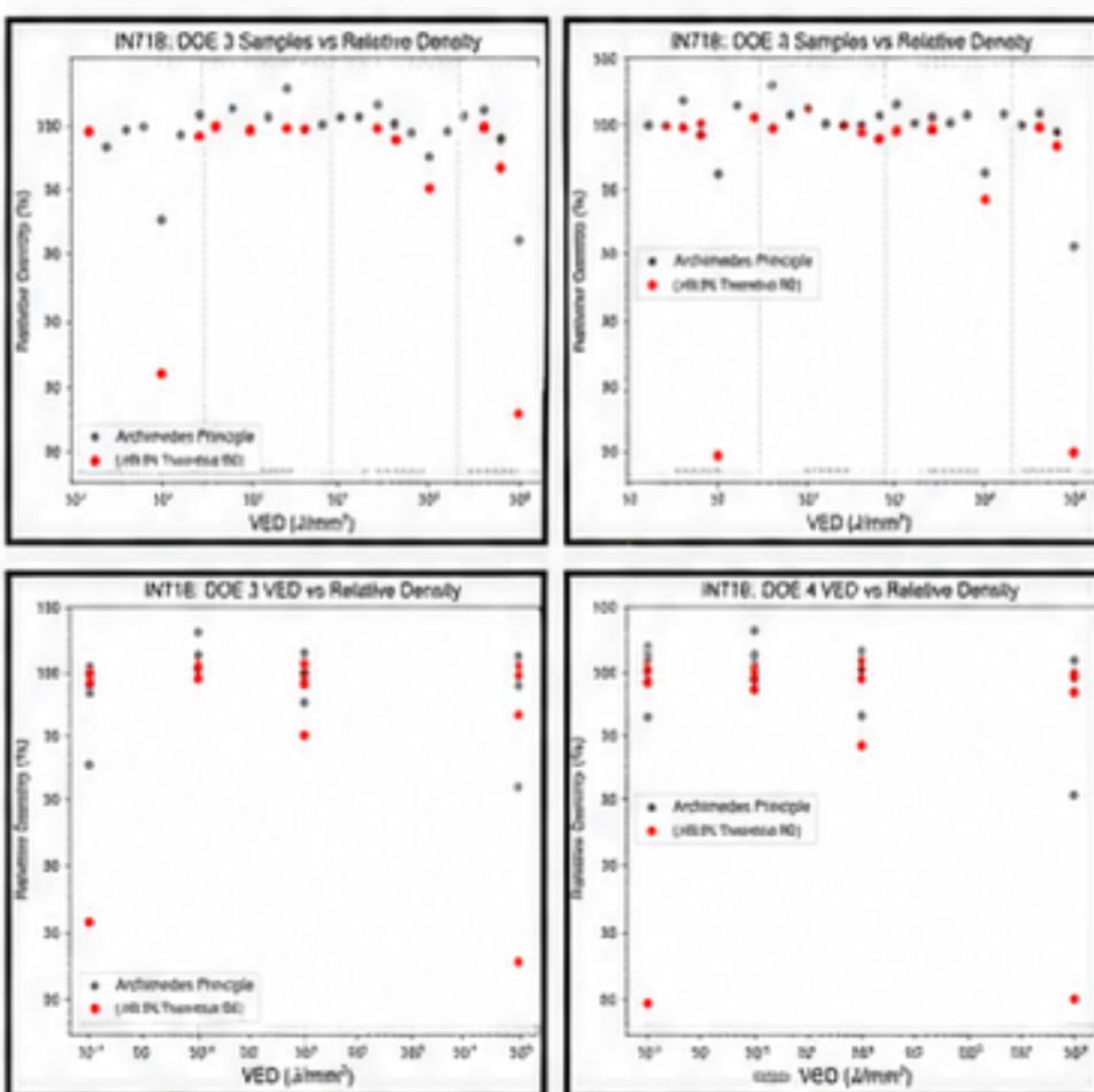
Results

DOE 1 & 2 - 316L Stainless Steel



- All VED had RD range's over 1% RD expect for DOE 2 VED 85
- 85 VED had narrowest ranges for RD compared to other VED's
- Sample 25 had significant Lack of Fusion (LoF)
- DOE 2 had narrower ranges overall

DOE 3 & 4 - Inconel 718



- All VED had RD range's over 1% expect for 70 (excluding sample 5)
- VED ranges of 70 (excluding sample 5) and 75 had narrowest ranges in RD
- Sample 5 and 25 experienced significant LoF leading to low RD values
- DOE 2 also had narrower ranges overall

Applications



Luo J¹

- Aerospace
- Automotive
- Biomedical
- Manufacturing
- Energy

Conclusions

- VED should be avoided as a unit of parameter development
- Archimedes method RD results had wider ranges compared to optical microscopy
- Scan speed may be more impactful than hatch spacing

Limitations

- Extraction process for DOE 1 was difficult due to dense support structures, causing irregular geometries for this DOE
- DOE's 3 & 4 were extracted using a chop saw which may have caused post fabrication heating, effects are likely very minimal
- Samples 5 (DOE 3 & 4) and 25 likely experienced high LoF due to process limitations as they were printed on the edge of the build plate

Archimedes vs Optical Microscopy



- Figures to the right show inaccuracies of archimedes as "lower" RD values via archimedes may actually have higher RD's via optical microscopy
- Archimedes typically overestimated Inconel 718 samples with RD
- Archimedes underestimated most of the samples in DOE 2, but was accurate for sample 70