

Effectiveness of Non-Toxic Surface Finishing Methods on Additively Manufactured Alloys



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Abstract

This project compares the effectiveness of two cavitation abrasive surface finishing (CASF) treatments on laser powder bed fusion (LPBF) manufactured parts. The first treatment involves a chemical pretreatment plus CASF processing, while the other process is CASF only. CRES 316, Ti-6Al-4V, and Inconel 718 samples were treated across multiple surface types using profilometry, SEM, and XRD, providing Sugino with shareable surface roughness, residual stress, and surface quality data for industry-relevant alloys.

Introduction

Can chemical pretreatment improve LPBF surface quality resulting from CASF treatment across different alloys and print orientations?

LPBF parts often have rough as-built surfaces caused by partially melted powder, layer lines, and print-orientation effects. This project compares CRES 316, Ti-6Al-4V, and Inconel 718 across upskin, downskin, and vertical surfaces to evaluate whether a nontoxic chemical pretreatment can improve the results of CASF treatments.

Cavitation Abrasive Surface Finishing (CASF)

CASF uses cavitation bubbles, abrasive particles, and high-pressure water flow to smooth LPBF metals. The process removes unmelted powder, reduces roughness, and can introduce compressive residual stress, improving surface quality without harsh chemical treatments.

Print Surfaces

Additively manufactured parts have three surface types. Downskin surfaces are particularly problematic as the as-built state has the roughest surface.

Materials

CRES 316	Use Case: Aerospace and healthcare
Ti-6Al-4V	Use Case: Aerospace and healthcare
Inconel 718	Use Case: Aerospace and automotive

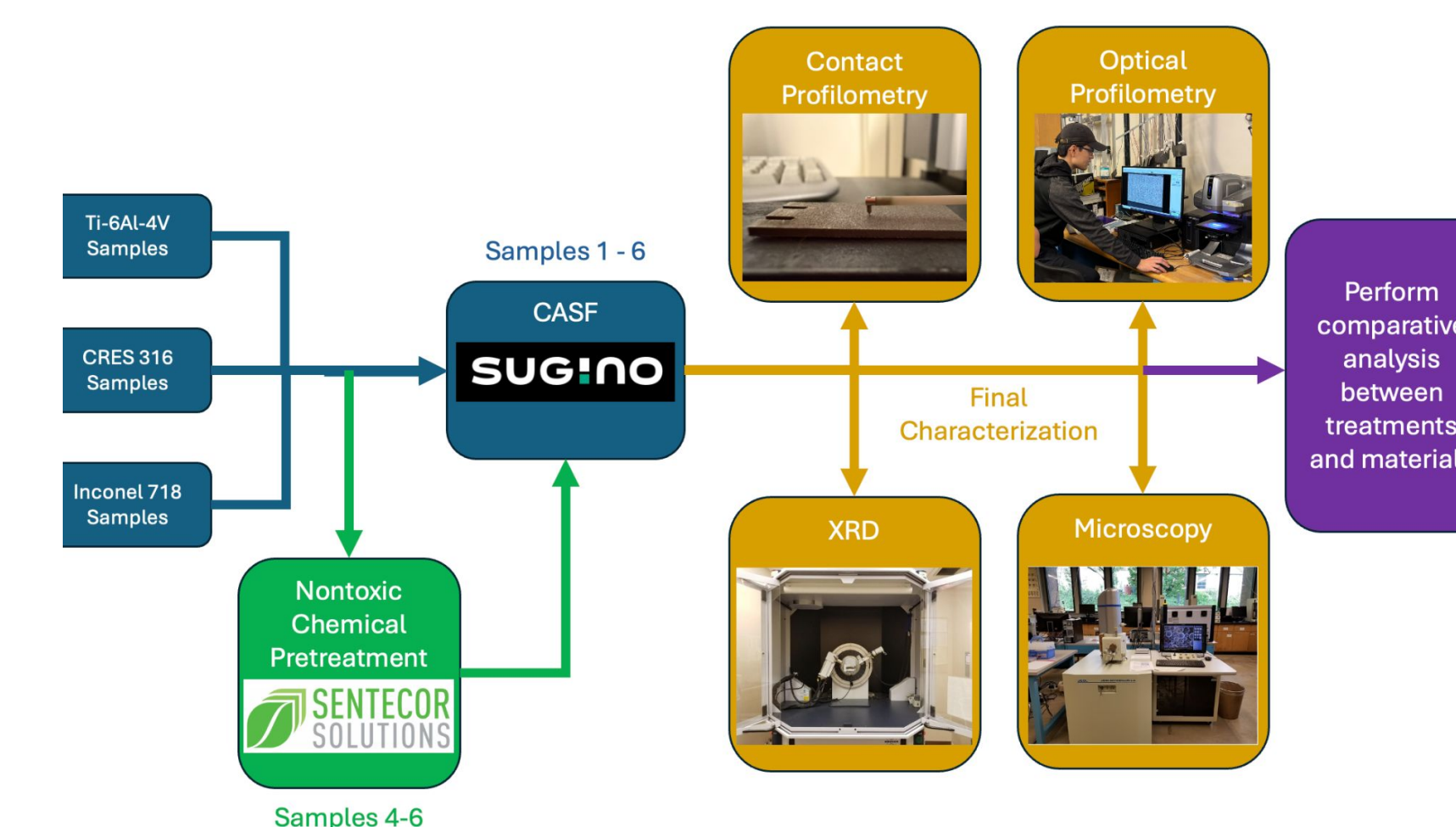
Methods

Surface Treatment

Three surface orientations were treated to investigate the potential surface improvements of various combinations of pretreatment and CASF.

Characterization and Test Protocol

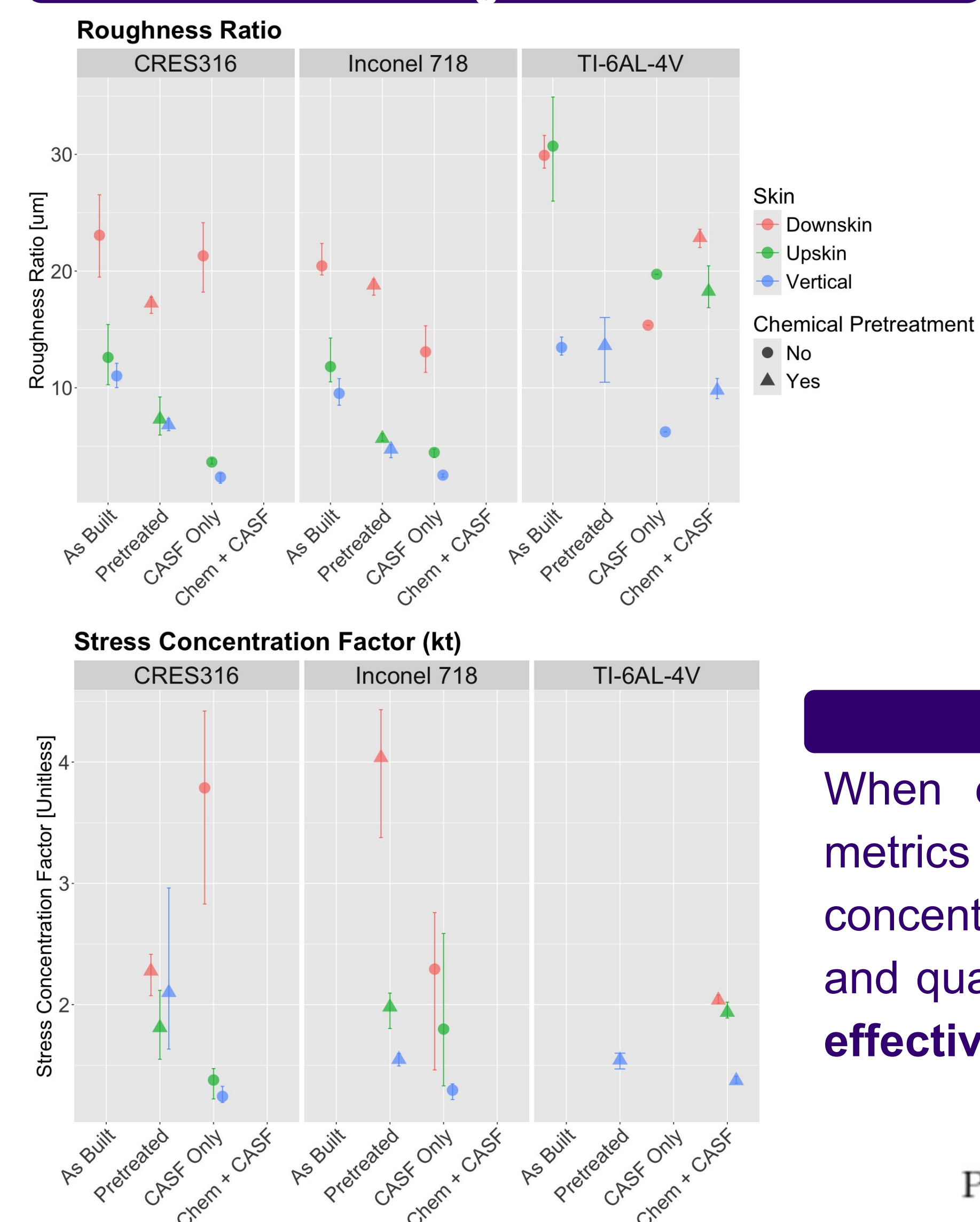
- **Contact and Optical Profilometry**
 - Roughness and Stress Concentration
- **Scanning Electron Microscopy**
- **X-Ray Diffraction**
 - Residual Stress



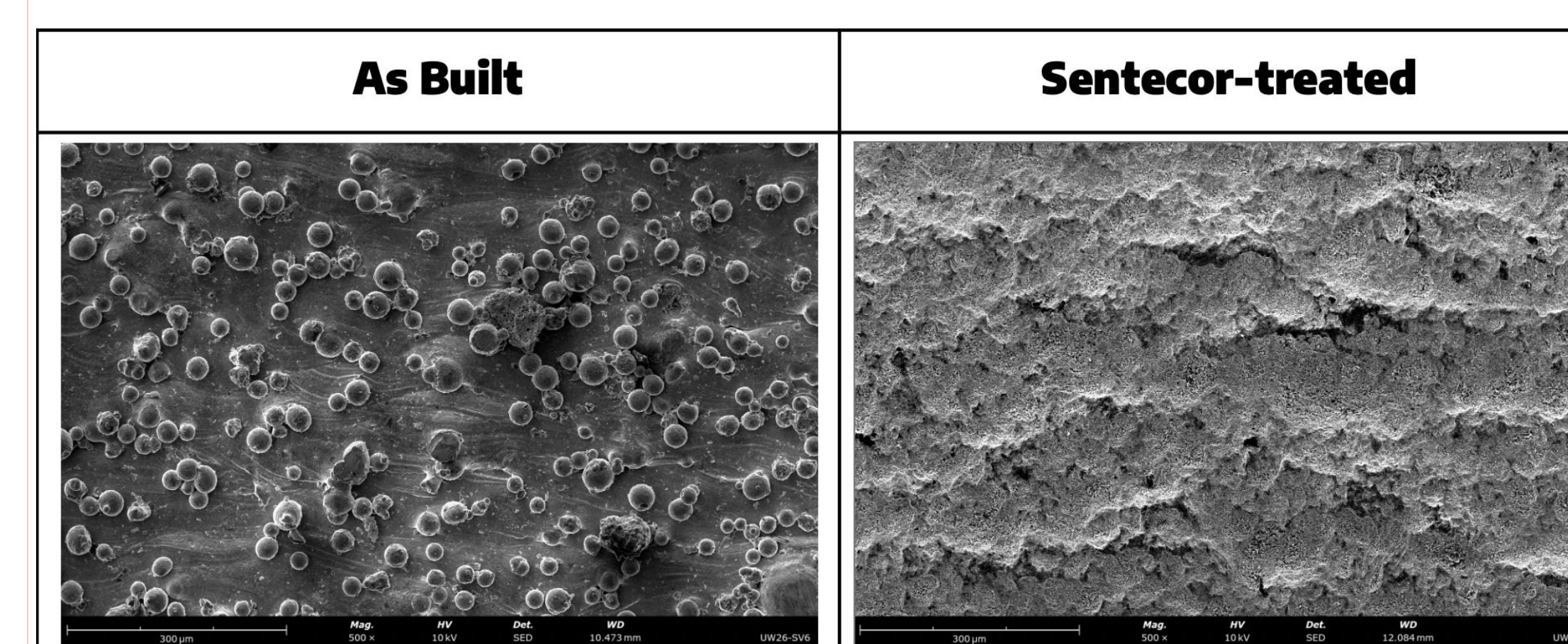
Results

Surface Roughness and Integrity

Roughness Ratio/Kt/Compressive Stress Diagrams



SEM Images of before and after of one material and each of the three surfaces



Process Effectiveness Factor

When evaluating surface finishing processes, comparing individual metrics like average roughness (R_a), residual stress, and stress concentration factor (k_t) fails to tell the whole story. To provide a clear and quantitative comparison between processes, a composite **process effectiveness score (PEF)** is proposed.

$$PEF = 0.4(\% \text{ reduction } R_{ratio}) + 0.4(\% \text{ increase } \sigma_r) + 0.2(\% \text{ reduction } k_t)$$

Results

Awaiting completed data collection

Conclusion

Awaiting completed data collection

Future Work

1. Fatigue testing

Acknowledgements