Evaluation of varying surface finishes on thin-walled blown powdered deposition Inconel 625

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Abstract

To advance additive manufacturing (AM) methods such as powder bed fusion (PBF) and blown powder deposition (BPD), it is necessary to characterize these parts and understand how they may differ from other processes such as powder metallurgy, cast, and wrought products. Further expansion of AM into new markets will rely upon development of various post-processing methods such as surface finishing. To evaluate the lower end of the deposition scale in blown powder deposition (BPD), nominal 1 mm thin wall Inconel 625 specimens were produced. This study evaluated the effect of various surface finishing methods such as Chemically Accelerated Vibratory Finishing (CAVF) and Chemical Milling (CM). The different surface finishing methods were compared by the resulting mechanical properties and microstructure in the thin-walled Inconel 625. This study found microstructural variations within the thin-walled BPD process that precluded the evaluation of different surface finish effects. This study highlights the need to link resulting microstructures with mechanical properties to understand the results.

Summary

- The high variability in the microstructure of the thin wall specimens created differences in the mechanical properties that cannot be attributed solely to the surface finishes.
- This indicates that greater process control needs to be developed and implemented for thin-walled metal additive parts first, before surface finishes can be compared effectively.
- Advances space technology research by showing how methods for qualifying additive parts in space or extra-terrestrial environments need to progress before these parts can be used in critical environments. High variability in microstructure for similar builds is detrimental to environments where supplies are not easily obtained.

Tension Data

- Smoother surface finish increases the tensile properties.
- The CAVF and CAVF/CM have higher tensile strengths than the CM and CM/CAVF.
- The smoother surface finishes also correlate to higher elongation in the experimental data.
- Despite the UTS measurements varying significantly, the yield strengths were fairly consistent across each specimen.

Surface Finishes

- A smoother surface finish can improve material properties.
- CM finished samples have a rougher surface finish indicated in (B) and (C).
- CAVF samples have a smoother surface finish indicated in (A) and (D).
- The table below depicts the average thickness of the samples in the build direction.

Impact/Conclusions

- Parts built using the same parameters often show different microstructures. This may be dependent on the parts location along the build or due to poor process controls.
- Tension testing of additively manufactured parts is often tricky to perform comparisons as the microstructures may differ dramatically.
- The specimens treated first with CAVF had a tendency to perform better in tension than other specimens, indicating that this surface finish may be superior to the others for increasing tensile properties.

Acknowledgements

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Table 1: Cross Section Thickness

<table>
<thead>
<tr>
<th>Surface Finish/Part Width</th>
<th>CAVF</th>
<th>CAVF/CM</th>
<th>CM</th>
<th>CM/CAVF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Thickness (µm)</td>
<td>909</td>
<td>884</td>
<td>802</td>
<td>907</td>
</tr>
<tr>
<td>Standard Deviation (µm)</td>
<td>57.1</td>
<td>38.8</td>
<td>42.0</td>
<td>74.1</td>
</tr>
</tbody>
</table>