Electropolishing Effects on Laser-based Powder Bed Fusion 316L Stainless Steel

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Abstract

The purpose of this study is to analyze electropolishing effects on the surface roughness of a laser-based powder bed fusion (L-BPF) 316L stainless steel and develop a relationship between electropolishing (EP) and corrosion potential. Surface roughness is characterized before and after EP using different techniques. The corrosion potential is also studied before and after the EP process and its measurements are compared. This study reveals that EP results in a reduction in surface roughness and increase in corrosion resistance in L-BPF 316L stainless steel.

Introduction

Additive manufacturing is a manufacturing process that builds a part by adding material layer by layer. Various metal parts can be produced with additive manufacturing through a method called laser powder bed fusion (L-PBF). This process involves spreading a layer of metal powder and fusing it together with a laser. There are many benefits to L-PBF and other additive manufacturing processes, including the ability to create complex geometries. However, L-BPF materials have a lower surface quality due to defects like the balling effect that increase corrosion and lower performance. L-BPF parts must undergo surface treatment in order to improve the quality and thus increase the use of additively manufactured parts in industry.

Methodology

Prepare Specimen

- Clean specimen with distilled water and ultrasonic agitation bath

Optical Microscope

-capture surface morphology of the specimen

White Light Interferometer

- Capture surface topography of the specimen

Surface Roughness Tester

- Measure the Ra and Rz values 10 times

- Ra: arithmetical mean roughness value (μm)
- Rz: mean roughness depth (μm)

Corrosion Resistance Test

- Fill beaker with PBS solution
- measure potential and current

Electropolishing

- Electrolyte made up of H_3PO_4 (85%), glycerol (99%)
- run for 10 minutes

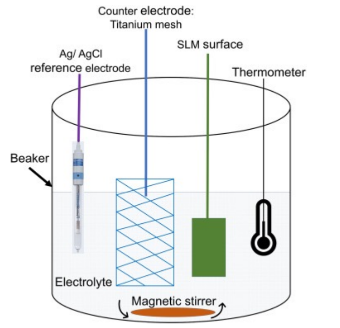

Fig. 1. Electrochemical workstation set up

Results

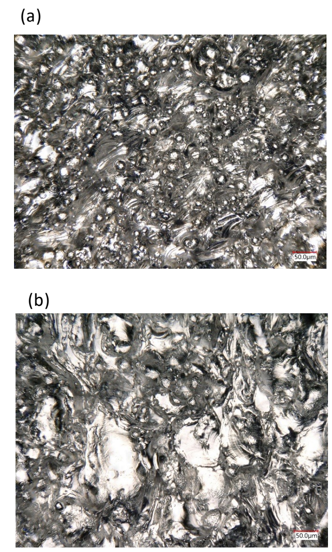

Fig. 2. optical microscope images of L-PBF surface (a) before and (b) after EP

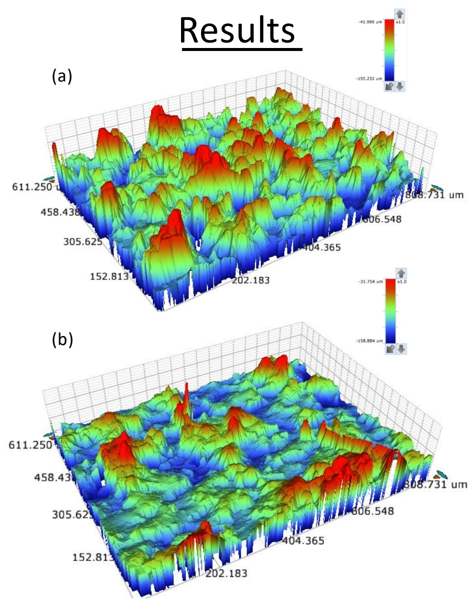

Fig. 3. white light interferometer topography of L-PBF surface (a) before and (b) after EP

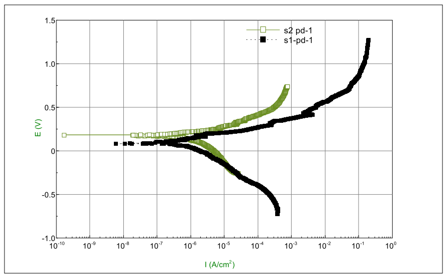

Fig. 4. Potentiodynamic polarization curves of L-PBF surface before (black) and after (green) EP

Table 1. Average of 10 measurements of Ra and Rz values before and after EP

	Average Ra Value (μm)	Average Rz Value (μm)
Raw	10.9548	59.4688
Polished	8.2441	46.255

Conclusion

- The EP process visibly reduced surface roughness in optical microscope images, revealing a reduced number of spherical formations from the balling effect
- The topography of the white light interferometer shows a reduction in the peaks and valleys of the surface
- Decrease in overall surface roughness as seen from Ra and Rz values
- Potentiodynamic curve shows an increase in corrosion potential after EP

References

S. Sun, M. Brandt, and M. Easton, "Powder Bed Fusion Processes," *Laser Additive Manufacturing*, pp. 55–77, 2017

A. Hemmasian Ettefagh, S. Guo, and J. Raush, "Corrosion performance of additively manufactured stainless steel parts: A Review," Additive Manufacturing, vol. 37, p. 101689, 2021.

U. Ali, H. Fayazfar, F. Ahmed, and E. Toyserkani, "Internal surface roughness enhancement of parts made by laser powder-bed fusion additive manufacturing," Vacuum, vol. 177, p. 109314, 2020.

H. Fayazfar, I. Rishmawi, and M. Vlasea, "Electrochemical-based surface enhancement of additively manufactured t i-6al-4v complex structures," Journal of Materials Engineering and Performance, vol. 30, no. 3, pp. 2245–2255, 2021.

P. Pendyala, M. S. Bobji, and G. Madras, "Evolution of surface roughness during electropolishing," Tribology Letters, vol. 55, no. 1, pp. 93–101, 2014.

M. Shen, C. Kang, and F. Fang, "Material removal characteristics of various surface features on selective laser melted 316L stainless steel during electropolishing," *Journal of Manufacturing Processes*, vol. 79, pp. 639–653, 2022.