EFFICIENT WATER FILTRATION THROUGH LASER POWDER BED FUSION FABRICATED POROUS FILTERS

Jady Xu[a], Shalini Singh[a], and Ahmed Qureshi[a]

[a] Department of Mechanical Engineering University of Alberta, Edmonton, AB

INTRODUCTION

- Additive Manufacturing (AM), or 3D printing, has revolutionized production processes by enabling the creation of intricate structures layer by layer.
- One standout technique within AM is Laser Powder Bed Fusion (LPBF),[1] which utilizes focused lasers to selectively melt and fuse metal powders, yielding precise, fully dense components with exceptional mechanical properties.
- This study explores the potential of LPBF in creating intricate porous filters using Stainless Steel (17-4PH), a versatile alloy known for its mechanical strength, chemical and corrosion resistance.
- Using the power of LPBF, our research aims to optimize the filtration[3] efficiency of these porous filters, pushing forward both 3D printing and filtration methods.[4]

Fig. 1 LPBF Machine

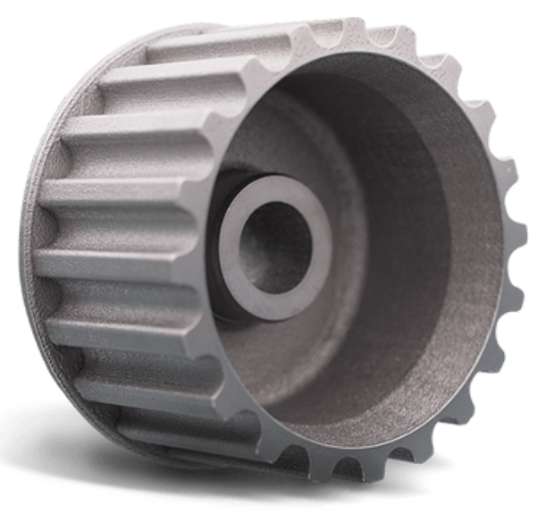

Fig. 2 17-4 PH Application

METHODS

1. CAD modeling in Solidworks
2. Convert file to STL
3. Transfer STL file to Orlas Suite
4. Add various parameters
5. Print
6. Remove Supports
7. Application

PROCESS

- Parameters are a crucial part of printing using LPBF and different materials have different optimal[2] parameters
- The most important parameters to consider for each material (powder) are laser power (W), scanning speed (mm/s), and hatch spacing (μm). For the stainless steel 17-4 PH we have printed 20 cubes with various parameters generated with ranges given to a software Minitab. After performing computed tomography scans with Dragonfly and analyzing the cubes closely, we identified the top three parameter sets that shows a significant amount of porosity which can be used for our filtration.

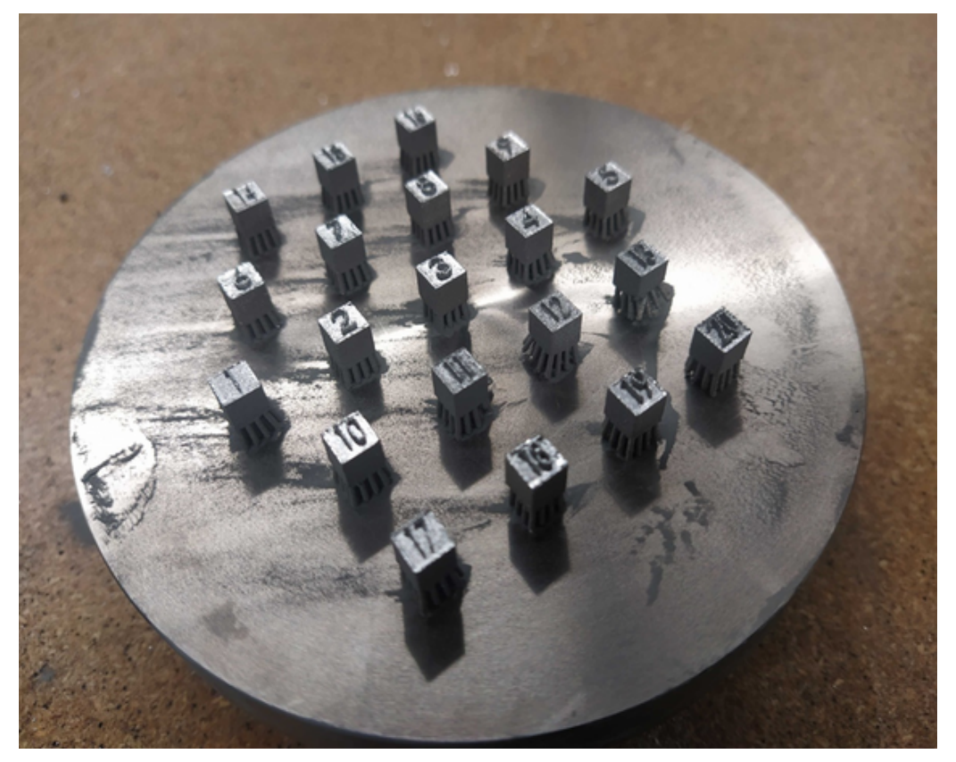

Fig. 3 LPBF printed samples

Stainless Steel 17-4 PH					
Sample #	Laser Power (W)	Scanning speed (mm/s)	Hatch Spacing (μm)	Energy density (J/mm^3)	Porosity %
1	80	1400	75	30.48	33.12±0.97
2	70	1600	95	18.42	51.81±1.54
3	60	1800	115	11.59	65.26±0.34

Table 1 - Optimal Parameters for 17-4 PH

- We designed cylinder water filters using Solidworks and with the 3D model design we have assigned different parameters to each filter.
- On a smaller scale, we started testing our printed samples through various methods. We found that the most effective filtration outcomes came from this setup, which contains a beaker full of water, a syringe and Teflon tape to seal off any air bubbles between the filter and syringe.

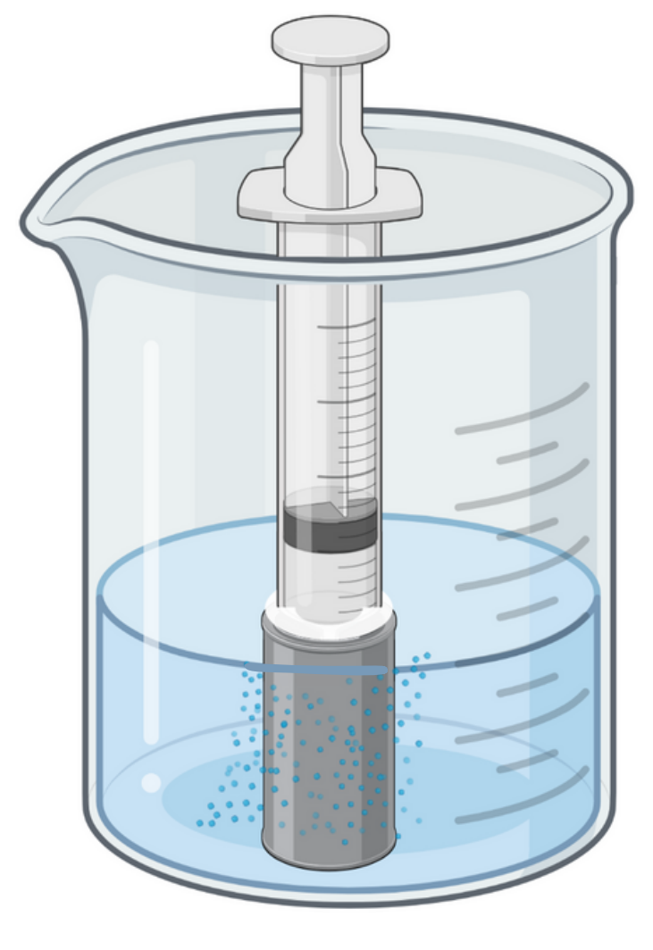

Fig. 4 Demonstration Apparatus

RESULTS

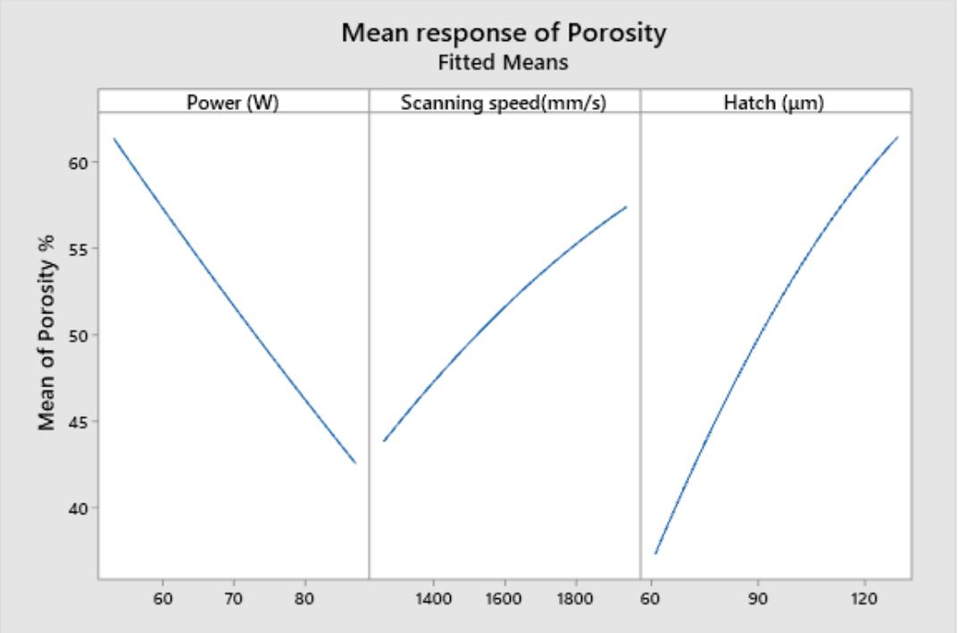

Fig. 5 Porosity v.s. Parameters

- Using a statistical software called Minitab we have collected sufficient data regarding the effects of porosity with change in each parameters. An increase in power results in a decrease of porosity % while an increase in scanning speed and hatch spacing results in an increase of porosity %.
- This explains why Sample 3 had remarkably low strength and high porosity including some holes around the filter wall.

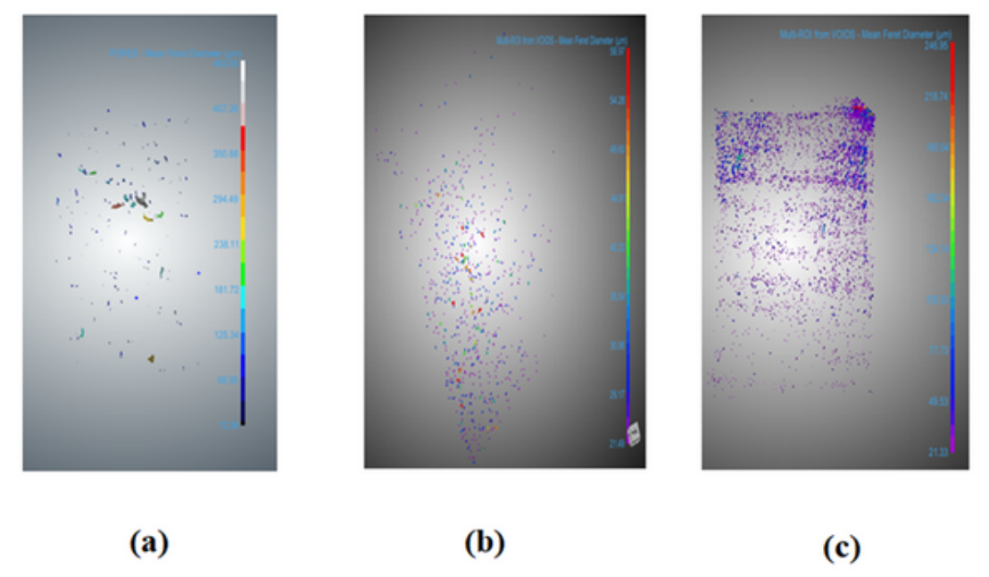

Fig. 6 Porosity Distribution Images a) Sample 1 b) Sample 2 c) Sample 3

- Sample 1 has the least porosity among the 3 filters at 33.12 ± 0.97%. The air bubbles were evenly distributed, filter wall was strong and had effective filtration. The tiny pores kept impurities trapped inside, making it perfect for precise filtering needs with liquid or gas.

Fig. 7 Sample 1 demonstration

- In contrast, Sample 2, with a porosity of 51.81 ± 1.54%, showed bigger pores that allowed more filtration. Plus, its uneven porosity across the filter meant it could lead to inaccurate filtration devices.

Fig. 8 Sample 2 demonstration

- However, Sample 3 (porosity: 65.26 ± 0.34%) faced issues – it had holes and broke during testing, so it could not effectively filter. Future experiments could increase laser power or decrease scanning speed/hatch spacing to overcome these issues.

CONCLUSION

- We have found that the set of parameters resulting in a 33.12 ± 0.97% porosity was the most efficient in filtration.
- More trials should be done to confirm these results.
- Metal additive manufacturing porous filters represent a groundbreaking advance in filtration, introducing customizable and high-performance solutions for diverse applications.
- This novel technology combines precision manufacturing with practical filtration demands, yielding enhanced efficiency and longevity. By bridging this innovation with real-world challenges, this research contributes to a more effective and sustainable approach to fluid separation, impacting industries ranging from water treatment to industrial processing.
- Filtration optimization is an extremely complicated problem and it is only with extensive research can we truly understand its underlying mechanisms.

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