

Reviewer 01:

Comments and Suggestions for Authors

The manufacturing process of L-PBF shows great potential for the making of complex structures as described correctly by the authors. But, the limitations in the materials used in this process are a real concern for engineers and manufacturers. As such, the results of this work could have the potential to aid in the design choices of those wanting to use L-PBF for microchannel heat exchangers. However, the methodology employed shows some flaws, and the numerical and experimental results diverge greatly. Additionally, the document lacks a lot of information which compromises reproducibility.

My comments to each section are thus presented below:

3.1 Workflow:

Comments 1. Naming the numerical section "Experiment" can give the opposite impression and there is no explanation on the "Parameter Setting" name.

Reply: Thank you for your feedback regarding the clarity of the flowchart. I have revised it to improve understanding. The unclear sections have been updated to 'Theoretical Plan,' which now includes the 'Tube CAD Model' and the 'L-PBF Printed Tube.' These are followed by 'Simulation' and 'Pressure Testing Device.'

To further clarify the experiment's structure, we have added the following sentence: "The experiment is structured around a theoretical framework comprising two main components: the 'Tube CAD Model' for simulation, and the 'L-PBF Printed Tube' for pressure testing."

The purpose of the CAD model simulation is to identify potential failure areas within the tube's internal structure under pressure conditions. In parallel, the pressure testing of the L-PBF printed tubes serves as an initial experimental method to validate these anticipated structural weaknesses and assess improvements aimed at enhancing pressure capacity.

[New content is in Line 170 to 173.]

3.2 Simulation:

Comments 1. This chapter lacks crucial information on the simulations. What are the mesh properties? What are the boundary conditions? What are the geometrical characteristics of the heat exchangers? What kind of solver is used?

I have added additional details regarding the simulation process, including mesh properties and boundary conditions, as explained in [Lines 283 to 296]. A new diagram has been included in Figure 6 to visually represent these aspects. Additionally, the geometrical characteristics

have been clarified with the introduction of Figure 5, along with corresponding explanations provided in [Lines 221 to 229]. The entire simulation process was conducted using Autodesk Inventor as the solver.

Comments 2. In table 2, the "Behaviour" value is "Iso". Iso is a prefix that means equal, but what is the full word? Isotropic?

Reply: Sorry for the confusion, I deleted the item of 'Iso' to avoid some uncertainty.

Comments 3. In Figure 4 there are 3 different heat exchangers, what are the differences between them? This should be disclosed in the text.

Reply: Thanks for noticing me. I made some classification to this part. Only three tubes were introduced here, 1.0x AlSi10Mg Tube, 1.5x AlSi10Mg Tube, and 1.0x Aluminium Tube. The details of their difference were also introduced in [Lines 221 to 229]. The first tube, referred to as 1.0x, is an AlSi10Mg microchannel tube with a wall thickness of 0.35 mm. The second, labelled 1.5x, is also an AlSi10Mg tube but with an increased wall thickness of 0.53 mm. The third tube is a 1.0x aluminium microchannel tube, identical in structure to the 1.0x AlSi10Mg tube but composed of a different material.

AlSi10Mg Tubes stands for the L-PBF printed tubes.

Comments 4. The figure is also too small, and should be enlarged to improve the document's readability (same for Figure 7 and 8)

Reply: Sure, now they are enlarged.

Comments 5. The figures seem to show a heterogeneous pattern on their coloring. Authors also describe inhomogeneities in the material, so I assume that it's somehow built into the model. What are these patterns and how did you implement material inhomogeneities into the model?

Reply: The color differences in the simulation results represent varying levels of von Mises stress and the corresponding safety factors across different areas of the tube. The heterogeneous distribution of von Mises stress is primarily influenced by the channel geometry, which can result in localized areas with lower safety factors. This observation provides insights into the potential origins of bubble formation, which will be discussed in the following chapter. The simulation experiments highlight the pressure distribution within the tube channels, demonstrating that variations in wall thickness and material composition can significantly enhance the mechanical performance of the tubes.

It is important to clarify that the material displayed in the simulation software is not a composite; rather, it represents a uniform material with consistent properties. The simulation follows its calculation methods to predict the behavior of the entire structure under different conditions.

Comments 6. In line 203 reads: "To establish a theoretical foundation for the experiment, research was conducted on the simulation process for the pressurized leakage detection experiment." Please clarify the relationship between leakage detection and the pressure distribution and safety coefficient analysis.

Reply: Thank you for noticing me, here are the explanations:

The relationship between leakage detection, pressure distribution, and safety coefficient analysis is integral to understanding the structural integrity of the microchannel tubes under pressurized conditions. The simulation process models the pressure distribution within the tube channels, identifying areas where stress concentrations are highest, which are more prone to structural failure and can manifest as leaks during physical pressure tests. This analysis helps predict potential failure points, allowing for targeted examination during the leakage detection experiment. The safety coefficient, or safety factor, measures the margin between the material's strength and the applied stress, evaluating the tube's ability to withstand internal pressures without failing. A lower safety factor in certain areas suggests a higher likelihood of failure under pressure, correlating with the leakage points observed in experiments. The theoretical foundation mentioned refers to using simulation to establish baseline expectations for tube performance under pressure, identifying weak points where leakage is likely to occur, guiding experimental design, and ensuring that observed leaks correspond to predicted failure areas. These simulations provide critical insights into how pressure distribution affects structural integrity, directly informing the leakage detection experiment and allowing for a comprehensive understanding of the tube's performance under pressurized conditions.

3.3 Results

Comments 1. Does the heterogeneity of the material have impact in the results? The stress distribution shown in Figure 7 is highly heterogeneous and complex. Could the authors could provide further insight on this behaviour?

Reply: In the original experiment, each of the three tubes yielded different results, with the 1.0x AlSi10Mg tube, produced using L-PBF, exhibiting the poorest performance. This outcome is likely due to the combined effects of the material properties and the structural wall thickness. Under identical pressure conditions, the mechanical properties of aluminum proved superior to those of AlSi10Mg. Additionally, the thicker wall of the tube allowed for

better stress distribution, reducing the likelihood of failure. These experimental findings validate the concept that both material selection and structural design, such as wall thickness, play crucial roles in determining the pressure capacity and overall performance of microchannel tubes.

Comments 2. All images lack axis titles and units.

Reply: Thank you for noticing me, I have edited those data chart.

Comments 3. In line 290 it states "it is important to recognise that these simulations often assume the product is virtually free of porosity". The use of the word "often" implies that there is no knowledge on whether the model used factors porosity.

Reply: Thanks for noticing, I delete the word of "often".

Comments 4. If simulations diverge greatly from experimental results as stated in line 276, how can these results help the design of L-PBF made heat exchangers? If porosity takes such a big role in the stress distribution, shouldn't the authors opt for a model that factors porosity?

Reply: This is an excellent question. The simulation experiments and pressure capacity tests are designed to complement each other, providing a comprehensive understanding of the tube's behavior under pressure. The simulation experiments offer detailed insights into the pressure distribution within the channels and help predict the specific locations where structural failure is likely to occur. On the other hand, the pressure capacity tests validate these predictions by revealing where failures manifest in reality, such as the appearance of bubbles on the upper and lower surfaces of the tube.

Regarding porosity, it is well known that L-PBF (Laser Powder Bed Fusion) printed parts inherently contain some degree of porosity, which significantly affects their mechanical properties. As mentioned in the article, the simulation software tends to exhibit better mechanical performance predictions because it assumes a more homogeneous material, without accounting for the complex void characteristics present in the actual printed parts. The real pressure capacity tests, however, reveal poorer results due to the presence of these voids, which contribute to brittle structural failure under certain pressure conditions.

In future work, we plan to enhance the accuracy of our simulations by incorporating small cavities within the model to better represent the voids present in the actual material. This approach will improve the correlation between our theoretical predictions and experimental results, providing a more robust foundation for understanding the impact of porosity on the mechanical integrity of L-PBF printed tubes.

Comments 5. How do the authors define the safety factor threshold of 3 labeled "Safety factor PBF"? Please clarify it in the text.

Reply: Yes, I have added a new sentence with a new reference. From [line 288 to line 194]

4.1 Experiment Preparation

Comments 1. The authors analyze different pressures (1 to 2 MPa) than in the numerical results (2 to 12 MPa). What is the reason behind this difference?

Reply: In the numerical results, the pressure test range was defined between 2 MPa and 12 MPa because the theoretical maximum pressure-bearing capacity could be significantly high. This broad interval was chosen based on experience to better understand the channel's pressure-bearing performance across a wide range. The primary goal of the numerical experiment is to explore how different materials and structural characteristics potentially influence the maximum pressure-bearing capacity and to analyze the pressure distribution within various regions of the channel. However, the actual pressure testing revealed that air leakage, indicative of brittle cracking, occurred at pressures below 2 MPa under the same material conditions. This suggests that the channel's structural integrity is compromised before reaching the upper limits of the numerical experiment. Therefore, it was deemed unnecessary to extend the pressure in the physical tests to the same range as the numerical simulations. The pressure test experiment primarily serves as a method to determine whether the channel meets the desired pressure-bearing performance, providing valuable insights into the material behavior under realistic conditions. Future work will aim to optimize these experiments by introducing more variables in the channel samples and seeking a more balanced correlation between the numerical results and the actual pressure capacity tests.

Comments 2. Experimental details need to be added such as: what camera was used; geometrical characteristics of the tube; Pressure Gauge measurements uncertainty; what L-PBF setup was used to manufacture the specific tubes used in the test facility so that the material properties are reproducible.



The camera used for capturing the images is the 'GoPro HERO 12 Black.' I have added this information to Appendix B alongside the corresponding images. Additionally, the tube geometry details have been included in the revised Figure 5. Regarding the printing settings,

the tubes were produced by a local company named YunYao. We requested that they print the tubes according to the parameters outlined in Table 2. However, they have declined to provide further details, citing business confidentiality.

Comments 3. How was pressure controled at the inlet? There should be a quantitative measurement of pressure drop in the tube.

Reply: We have a pressure reducing valve as shown in the figure to regulate a constant nitrogen feed, and the air pressure fed into the pipe is judged by the indication of the gauge on this valve.

4.2 Methodology

Comments 1. Can the "nearly no bubbles" regime be an indication of leakages nonetheless? Bubbles even if small and few can be a sign of an early leakage. Please clarify in the text.

Reply: Thanks for noticing, in our proposal theory, "nearly no bubbles" shall be considered as no leakages. I add this information to the Figure 12.

Comments 2. How many repetitions were performed for each type of tube?

Reply: Due to funding issues, we have only done one experiment for each type of tube so far and will do more in the future.

4.3 Results

Comments 1. Table 4 and 5 are exactly the same. So the table from the benchmark tests is missing although the description is correctly provided.

Reply: Sorry my mistake, already fixed.

Comments 2. If photos of all cases were taken, can they be presented in this section for an easy comparison between tubes at different pressures.

Reply: Sure, I have added them in the appendix.

Comments 3. It is stated that some bubbles may be due to the water being non degassified (line 393). How was the distinction made between these two types of

bubbles in the analysis?

Reply: In the experiments with aluminium tubes, the phenomenon of tiny bubbles did occur at 60 min. Since it is almost unlikely that the aluminium tube used as a reference experiment would show weak bubbles, we conclude that those bubbles at the 60-minute mark could be caused by dissolved air in the water; as for the L-PBF printed tube, since those tiny bubbles appeared before reaching the 60-minute mark, we can reasonably suspect that the tiny bubbles in the L-PBF could be caused by produced by tiny cracks in the pipe, and the two kinds of bubbles can be distinguished from each other according to this understanding.

5 and 6 Discussion

Comments 1. There are no mentions of the numerical work in the conclusions or discussion. Please comment on how can the results from the numerical work support the conclusions of this work.

Reply: Thanks for noticing, now I have modified the conclusion part. The new version is from [Line 457 to line 494].

Comments 2. The conclusion refers to the article as a "dissertation".

Comments on the Quality of English Language

Some minor English errors are present in the text.

Figure 5 and 6 spell "Safty" instead of Safety

Figure 9 has "Pressure Guage" instead of Pressure Gauge

Reply: I tried to fix them. Now might in an appropriate stage.

Reviewer 02:

Comments and Suggestions for Authors

Comments 1. The writing of the abstract needs to be improved by adding key results to the manuscript.

Reply: Thanks for noticing, I have modified it with some key results and main purpose of each experiment.

Comments 2. In the case of micro and small bubbles, it is recommended to use quantitative values to define them.

Reply: Thanks for this valuable recommendation, this shall be processed in future works.

Comments 3. Conclusions are good with the detailed results, however, it is recommended to rewrite more qualitatively rather than quantitatively.

Reply: Yes, I have made a better conclusion, with some key summary from experiment result.

Comments 4. In Figure 12. the presence of white regions must be indicated with their names.

Reply: Sure, I have mentioned them in the following section of new figure 15. Those white areas are impurities, probably caused by the unfortunate contamination of the sample when it was shipped, and because they are not conductive, they appear oddly fast and white under the microscope.

Comments 5. Figure 12f seems to show the formation of oxidation along the deposited layers, does these are tested for chemical analysis?

Reply: Thanks for this valuable recommendation, this shall be processed in future works.

Comments 6. In the case of Tables 3 to 5, the Leakage level should be presented using a numerical value.

Reply: This is a valuable suggestion, but current equipment limitations make it difficult to quantify bubble features for the time being, but in the future we will consider using a high-resolution camera to capture bubble features and quantify them.

Comments 7. In Figure 11, please provide the scale bar and what is the porosity amount in the deposited parts.

Reply: Thanks for noticing. I have adjust the original Figure 11, now the scale bar can been seen clearly. But for the porosity amount in the deposited parts, it is hard to provide now, there haven't been an authorial definition of evaluating the L-PBF Printed MCHE tube's porosity, it is not appropriate for us to put such information here following our own understanding. But I believe that there will be a fine definition in the future.

Comments 8. Is the main purpose of these tubes to transport he pressurized gases? what about the heat loss and frictional effects?

Reply: Sorry for the confusion. The primary objective of the experiment was to explore the pressure capacity limitations of the L-PBF printed tube. The simulation experiment was designed to complement this by providing insights into the potential behavior and failure mechanisms during the actual pressure capacity tests, without focusing on heat transfer performance. Nitrogen was used as the pressurization agent because the experiment was solely concerned with pressure capacity, and there was no requirement to test with a refrigerant. I have incorporated this explanation into the Introduction section, and I appreciate your suggestion.

Comments 9. The technical content of the manuscript must be improved.

Reply: Appreciate for you understanding, I have adjusted a better version of the manuscript with guidance of other reviewers' idea. You can check them now.