流体动力与机电系统国家重点实验室
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Wear performance of metal parts fabricated by selective laser melting: a literature review

Key words:
Wear; Selective laser melting; Additive manufacturing; Lubrication; Pores

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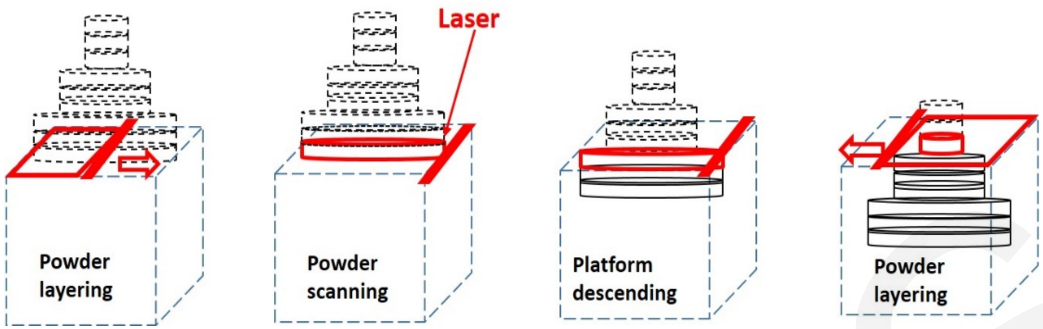
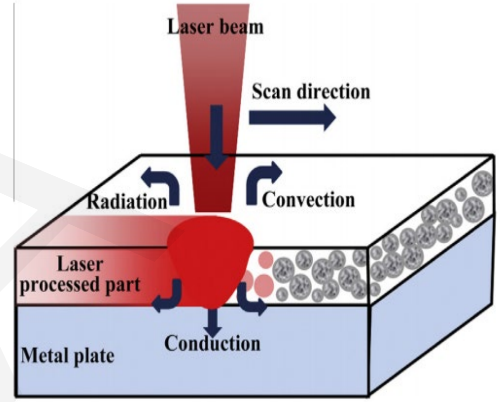


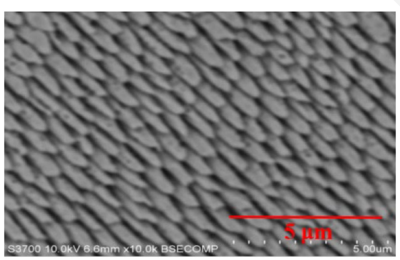
Working process of selective laser melting (SLM)



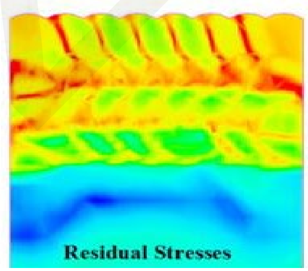
Li and Gu, 2014

- Small laser spot (<100μm)
- Fast scanning speed (can be over 7m/s)
- High laser power

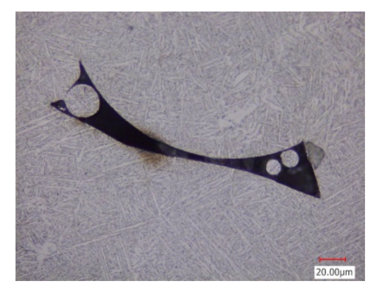
Sharp and repeated heating/cooling cycles



Fine grains



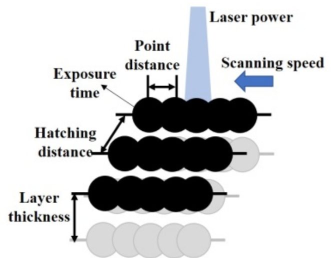
Large residue stress



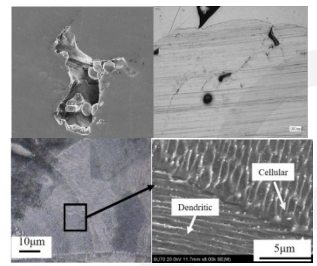
Pores and cracks

Wear performance of metal parts fabricated by selective laser melting: a literature review

Many researchers studied the relations among SLM processing parameters, resultant microstructures, and mechanical properties.



Laser processing parameters

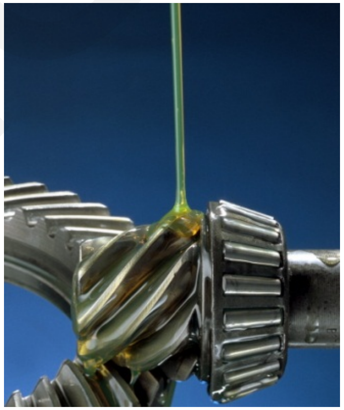


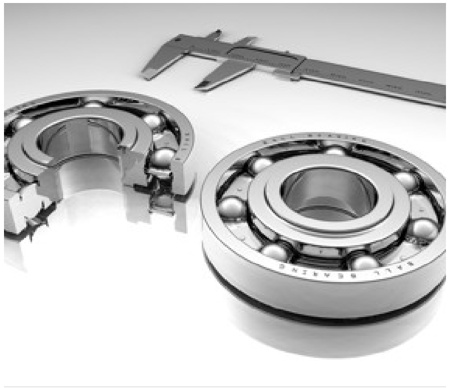
Material microstructures

Mechanical properties

Wear is crucial for contacts all over machine elements.

What is wear performance of a part manufactured using SLM?





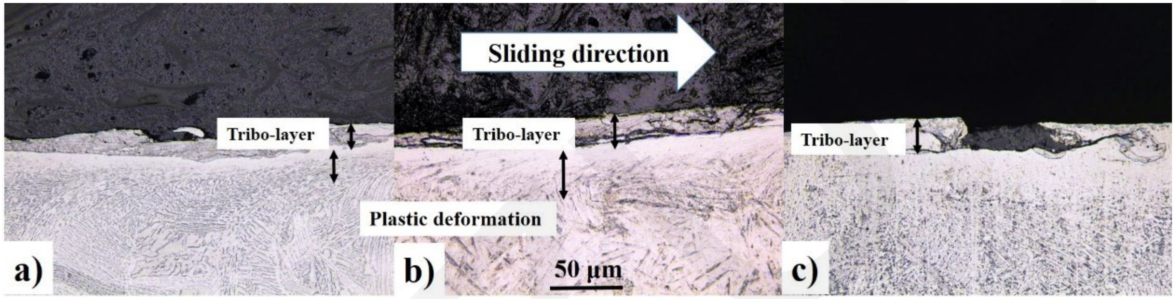
Wear performance of metal parts fabricated by selective laser melting: a literature review

1 Dry conditions

- SLM materials: steels; Ti and Ti alloys; Al-Si alloy; Inconel
- Contact types: point contact; face contact
- Motion: sliding; reciprocating
- Contact pressure: >1 GPa (point contact); 0.5-5 Mpa (face contact)
- Speed: 0.1-1 m/s (sliding); 10-50Hz (reciprocating contact)
- Wear rate: lower than conventionally processed parts (wear mechanism does not differ much); increases with increased pores. Wear resistance can be enhanced by having composite materials.

2 Boundary lubrication conditions

Ti6Al4V and 316L stainless steel was tested. The wear rates are lower than conventionally processed parts due to fine grains and high hardness. SLMed parts also benefit from a protective tribo-layer.

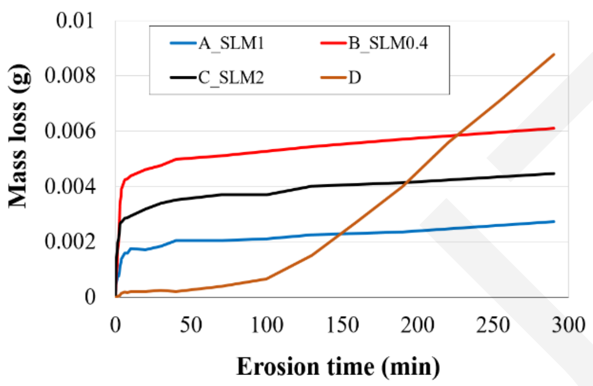


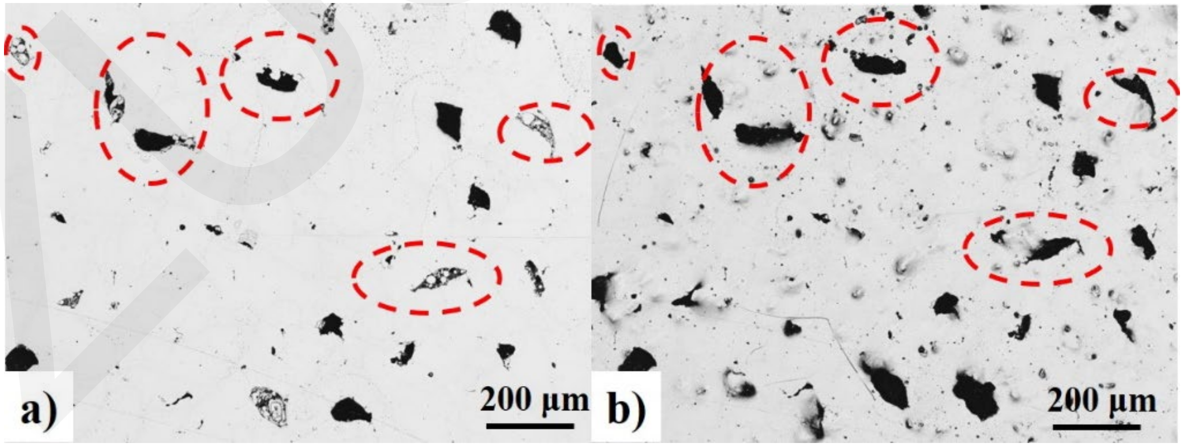
3 Corrosion conditions

SLMed aluminum alloy, Ti alloy, and steel were tested. Microstructure, building directions, and pores are directly related to the corrosion resistance.

4 Erosive wear

The cavitation erosion behavior has been studied. A very different erosion behavior was found regarding the AlSi10Mg. In the beginning, the SLMed parts had extremely high erosion rate dur to the presence of unmelted particles inside pores. In the steady-state stage, SLMed parts had very low erosion rate. Laser scanning speeds affect the sample density and the number of pores, which further influence the maximum erosion rate.





(a) the original state of the surface; (b) after 30 s.

Future trends

- However, research has been barely performed when a lubricant film is fully or partially formed. In that case, the influence of a lubricant film can outweigh that of the SLMed microstructures. Surface pores may positively influence the formation of the lubricating film.
- The conclusion of cavitation erosion can be used in fields where materials suffer from cavitation erosion such as hydraulics and aerospace. More research needs to be performed in order to confirm that the phenomenon does not solely belong to the aluminum alloy.
- The interaction between pores and counterparts (or lubricant films) under various contact conditions is worth studying. The final step is to positively control the pores and microstructures of the SLMed materials to achieve low friction and wear by adjusting the SLM processing parameters.