Sliding wear and induced-microstructure of Ti-6Al-4V alloys: Effect of additive laser technology

Nan Kang [1, 2]*, Mohamed El Mansori[1], Enhao Feng[2, 4], Chunling Zhao [3]*, Yu Zhao[3], Xin Lin[2]

[1] Arts et Métiers Institute of Technology, MSMP, HESAM Université, F-51006 Châlons-en-Champagne, France
[2] State Key Laboratory of Solidification Processing, Northwestern Polytechnical University, Xi'an Shaanxi 710072, PR China.
[3] AVECC Hunan Aviation Powerplant research institute, Zhuzhou, P.R. China
[4] Xi'an High Voltage Apparatus Research Institute Co.,Ltd, Xi'an, Shaanxi 710077,P.R.China
*Corresponding author: nan.kang@ensam.eu

In this work, a comparison study on the sliding wear behavior and microstructural evolution of Ti64 (Ti-6Al-4V) samples, which were prepared using laser powder bed fusion (L-PBF) and laser directed energy deposition (L-DED) technologies, is carried out for better understanding the friction and wear mechanism of laser additive manufactured Ti64 alloys. After dry sliding wear, the cross-sectional microstructure of pin can be divided into three regions: (I) tribolayer, (II) plastic deformation and (III) base materials zoom. Mention that the L-PBF processed one shows smaller plastic deformation aera at sub-surface region than the others, due to its low ductility.

Keywords: Additive manufacturing; Laser powder bed fusion; Laser directed energy deposition; Ti-6Al-4V; Wear; Microstructure.

1. Introduction

Laser additive manufacturing (LAM) processed Ti64 alloy is widely recognized as one of the most important objectives for aeronautics and astronautics as functional strategic operating parts [1]. However, the area of increased activity research concerns in general the induced mechanical performance and particularly the wear of sliding LAM processed Ti64 surfaces. For this reason, the study of friction and wear as induced by the effect of the additive technology is important. This research work emphasizes the sliding wear and friction behaviours of laser powder bed fusion (L-PBF) and laser directed energy deposition (L-DED) processed Ti64 sample with focus on special microstructure feature and induced evolutions. The wrought Ti64 sample is used as reference for comparison with the properties of manufactured L-PBF and L-DED processed Ti64 sample.

2. Methods

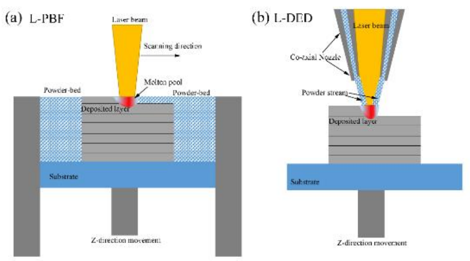

Figure 1 The schematic illustration of (a) L-PBF and (b) L-DED systems using in this work.

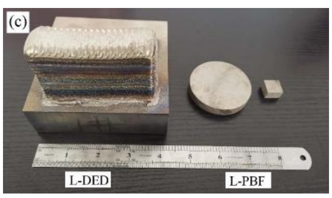

Figure 2 Powder morphologies for (a) L-PBF and (b) L-DED processes and (c) as-prepared samples.

2.1. Results

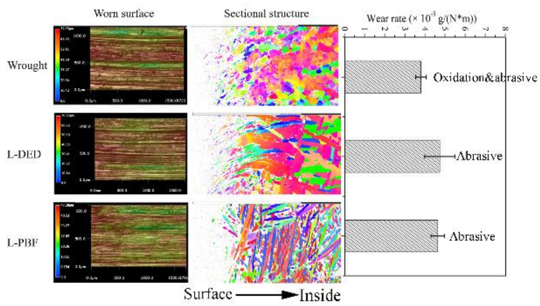

Figure 3: Wear behavior of L-PBF and L-DED processed Ti64 sample.

3. Discussion

In both L-PBF and L-DED cases, the as-fabricated samples exhibit a nonequilibrium features with lath α-Ti. On the other hand, given to the high cooling rate (10^5K/s) of L-PBF technology, the as-fabricated sample presents a finer microstructure than the one processed by L-DED additive technology. Considering the hardness value from multi-scales: the micro-hardness of L-DED processed sample shows the highest value about of 400 Hv among them. But, for the nano-hardness results, the wrought one is higher (about 4.7GPa) than the other two samples. Combining them with wear rate, it can be concluded that the nano-hardness is more suitable for the wear rate prediction in case of mild wear behavior. On the other hand, the cross-sectional analysis results indicate that L-PBF processed sample possesses a smaller plastic deformation zoom than that of L-DED sample, which is attributed to its low ductility induced low wear resistance.

References

[1] S. Liu. et al., "Additive manufacturing of Ti6Al4V alloy: A review" Materials & Design, 164, 2019, 107552.