

Abstract

Ti-6Al-4V is a titanium alpha-beta ($\alpha+\beta$) alloy used in the aerospace industry. The CSIR-National Laser Centre encountered problems building large Ti-6Al-4V parts by additive manufacturing using the AeroswiftTM machine. The acicular α' microstructure of Ti-6Al-4V had low fracture toughness and ductility, resulting in the part being unable to withstand the residual stresses, and delaminating during processing.

To solve this problem, *in situ* alloying of Ti-6Al-4V with a ductile beta (β) stabilizer, 10 wt% Mo, was investigated since the β phase is more ductile. Samples were manufactured on the powder bed fusion (PBF) and directed energy deposition (DED) platforms. A commercial β -Ti alloy (Ti-3Al-8V-6Cr-4Zr-4Mo) was also investigated for comparison.

The Ti-6Al-4V, Ti-6Al-4V+10 wt% Mo and β -Ti alloy samples were manufactured on a selective laser melting (SLM) machine (PBF process), and Ti-6Al-4V+10 wt% Mo samples were made on a LENSTM machine (DED process). The samples were subsequently examined by optical, scanning electron microscopy (SEM) with electron diffraction X-ray spectroscopy (EDX) and electron backscatter diffraction (EBSD), X-ray diffraction (XRD), and were tested for hardness.

Increased energy density changed the shape of pores, and decreased the porosity. The microstructure of PBF-produced Ti-6Al-4V+10 wt% Mo was inhomogeneous, with unmelted Mo particles and inconsistent hardness values, depending on Mo content. A PBF sample was tested for micro-galvanic corrosion, and the more Mo particles were attacked. Thus, no further testing was conducted on this alloy. The overall alloy hardness (302 HV_{0.3}) was lower than for Ti-6Al-4V (360 HV_{0.3}), indicating that Mo had a softening effect. When produced by DED, Ti-6Al-4V+10 wt% Mo was more homogeneous, with very little unmelted Mo, and hardness was higher (397 HV_{0.3}) than for the PBF sample (302 HV_{0.3}). The commercial β -Ti alloy had a fully β microstructure, with a 309 HV_{0.3} hardness, which was lower than that of Ti-6Al-4V (360 HV_{0.3}). The ultimate tensile strength of Ti-6Al-4V (1130 MPa) was higher than for the commercial β -Ti alloy (863 MPa). The elongation of the commercial β -Ti alloy (30%) was much higher than Ti-6Al-4V (9%).