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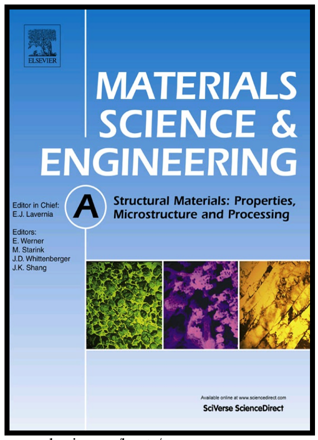

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A Study of the Microstructures and Mechanical Properties of Ti6Al4V Fabricated by SLM under vacuum

Bin Zhou[a,b,c], Jun Zhou[a,b,c], Hongxin Li[a,b,c], Feng Lin[a,b,c*]

[a]*Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China*

[b]*Biomanufacturing and Rapid Forming Technology Key Laboratory of Beijing, China*

[c]*Key Laboratory for Advanced Materials Processing Technology, Ministry of Education of China*

Abstract

Ti6Al4V components with complex structures, excellent performance and good surface quality, can be fabricated by selective laser melting (SLM). The conventional SLM process is carried out in an inert gas filled chamber, at slightly greater pressure than ambient, to avoid oxidation at high temperature. However, the inert gas may cause pores in as-fabricated parts. In this study, the SLM process was carried out under vacuum in order to improve the quality of the SLM-fabricated Ti6Al4V samples. The as-fabricated Ti6Al4V samples then were subjected to hot-isostatic pressure (HIP). The remaining porosity was evaluated using X-ray computed tomography (CT). The microstructures and mechanical properties of the samples were evaluated with and without HIP. The test results showed that SLM under vacuum could reduce the porosity of Ti6Al4V samples, compared to material that was produced using the conventional SLM process. After HIP, porosity could be further reduced and the Ti6Al4V samples could achieve better elongation.

Keywords: Selective laser melting; Vacuum; Ti6Al4V; HIP; X-ray CT

1. Introduction

Additive manufacturing technologies have attracted increasing attention because the products have many important applications due to their flexibility in design, possible complexity and the short lead times for production. The selective laser melting (SLM) process is a powder-based additive manufacturing technology, which utilizes a focused laser beam to melt the powder and produce parts, layer by layer, with high dimensional accuracy. Thus, SLM can be applied in the manufacture of impellers, blades, for porous structures and to produce medical implants [1-4].

The conventional SLM process is carried out in an inert gas filled chamber, at a pressure that is slightly greater than the ambient air pressure. Inert gas can prevent oxidation of the components by the high temperatures caused by the laser. However, the inert gas cannot melt into the lattice and, if not removed in time, the gas will be left inside the component, leading to porosity which can seriously affect the performance of SLM-fabricated parts [5-7]. While under vacuum, the volume of residual gas will be greatly reduced and therefore the quality of SLM-fabricated parts will be improved. Also, the metal spatter caused by gas expansion can be eliminated during laser irradiation [8, 9]. However, the evaporation of volatile materials such as Al is much greater under vacuum and, in consequence, it is possible that the chemical composition of as-fabricated parts will change [10, 11]. More significantly, the lenses of the laser will be 'contaminated' with metal vapor and, as a result, the SLM scanning process is detrimentally affected.