Abstract

Selective laser melting (SLM) technique is a promising 3D printing technique used in the aerospace application, amongst other additive manufacturing (AM) techniques. Parallel to SLM, Ti6Al4V is a suitable alloy in the aerospace industry because of the advantages it offers which include superior combination of strength and reduced weight. The advantages of producing Ti6Al4V by SLM manufacturing process results in an increasing demand of SLM Ti6Al4V parts in the industry. The Aeroswift^{TM} SLM machine, available at Council for Scientific and Industrial Research (CSIR), is capable of producing components using high speed and high-power laser of up to 5 kW.

The ability of Aeroswift^{TM} machine to print components using high speed and power, result in accelerated production of high precision parts, which leads to reduced production times. However, because of high cooling rates together with large thermal gradients that accompany the SLM technique, the produced components exhibit an acicular martensitic α'-phase. The martensitic α'-phase (which leads to low ductility) formed during the production of SLM produced Ti6Al4V components make their components not to achieve the same mechanical properties compared to their wrought counter parts.

This study is aimed at using post heat treatment to overcome challenges presented by SLM process by improving the microstructure and mechanical properties of Ti6Al4V coupons. Ti6Al4V samples were produced on a high-speed powder bed Aeroswift^{TM} machine and then heat treated under different conditions. Microstructural and phase analyses were performed by using optical microscope (OM) and the scanning electron microscope (SEM). Mechanical properties of the samples were evaluated by performing Vickers micro-hardness and tensile tests.

The as-built microstructure was characterized by large columnar prior β grains. Sharp acicular martensite α'-phase was found inside the prior β grains. Heat treatment was applied to the as-produced samples to transform the metastable martensitic α' structure into stable phases, thereby improving the microstructure.

It was found that heat treating at 700°C does not transform the martensitic α'-phase. Heat treating at 950°C and 1000°C transformed the martensite α'-phase into fully lamella α + β. Moreover, 1000°C changed the columnar β grains to equiaxed morphology. The hardness was found to decrease with increasing heat treatment temperature. Furthermore, heat treatment at 1000°C followed by water quenching (WQ) and air cooling (AC) initiated formation of a finer martensite α'-phase which resulted in increased hardness. Heat treating at 1000°C for 2 hrs, cooling by furnace cooling (FC) improved the ductility to at least 13%. Furthermore, yield strength (YS) and ultimate tensile strength (UTS) were found to have decreased after heat treatment.