

Abstract

Laser Powder Bed Fusion (LPBF) stands as an advanced metal additive manufacturing process, enabling the creation of components with intricate shapes through the localized melting of successive layers of powders using a computer-controlled laser beam. In recent years, LPBF has garnered considerable attention, not only for its inherent benefits in providing high design flexibility but also for the opportunities/challenges it presents from a materials perspective. The spectrum of printable alloys is constrained due to its unconventional processing conditions. Among the limited alloys that exhibit good printability, there is growing interest in a newly developed high-strength aluminium alloy (A20X) for additive manufacturing. The alloy was developed and patented by Aeromet International Ltd, UK.

In the present thesis, the commercial high strength A20X alloy was processed by LPBF, and their post-processing behaviour was investigated. Firstly, the printability of the A20X alloy was investigated. The alloy was easy to process and possess a wide processing window with high relative densities. Being a precipitation hardening alloy, various post-processing conditions were investigated as they have remarkable affect on the mechanical behaviour of the printed parts.

The post-processing heat treatment investigated were: Artificial aging (T6 and T7), natural aging (T4) and hot isostatic pressing (HIPing).

To understand the post-processing behaviour of A20X alloy, a conventional long-T6 heat treatment was employed and its microstructural evolution and mechanical behaviour was investigated. Post to the analysis, a new heat treatment (short-T6) was proposed and compared with the long-T6. The short-T6 heat treatment offers superior ductility as compared to long-T6 along with a slight improvement in strength. It was discovered that the alloy also responds well to the T4 condition and achieved its peak hardness in around 20 days at room temperature (28 °C). The alloy in its T4 state possess a combination of good-strength and high-ductility. An insight into the structure-property relationship was obtained by evaluating various strengthening mechanism and their contribution to the overall yield strength of the alloy. The thesis also has a dedicated chapter on understanding the strain hardening behaviour and failure mechanism of various post-processing conditions. Finally, the effect of HIP (most commonly employed techniques for AM parts) was studied and compared with the short-T6 condition.