Characterization of the mechanical properties of a Zr-modified Al7075 processed by Laser Powder Bed Fusion

Benoît Mansoz[1], Nicolas Nothomb[2], Masoud Ahmadi[3], William Mottay[4], Hosni Idrissi[5], Aude Simar[6]

[1] Institute of Mechanics, Materials and Civil Engineering, UCLouvain, Louvain-la-Neuve, Belgium, Belgium.
benoit.mansoz@uclouvain.be
[2] Institute of Mechanics, Materials and Civil Engineering, UCLouvain, Louvain-la-Neuve, Belgium, Belgium.
nicolas.nothomb@uclouvain.be
[3] Institute of Mechanics, Materials and Civil Engineering, UCLouvain, Louvain-la-Neuve, Belgium, Belgium.
masoud.ahmadi@uclouvain.be
[4] IM2NP, UMR CNRS 7334, Université de Toulon, Aix-Marseille Université, France. william.mottay@im2np.fr
[5] Institute of Mechanics, Materials and Civil Engineering, UCLouvain, Louvain-la-Neuve, Belgium, Belgium.
hosni.idrissi@uclouvain.be
[6] Institute of Mechanics, Materials and Civil Engineering, UCLouvain, Louvain-la-Neuve, Belgium, Belgium.
aude.simar@uclouvain.be

Paper ID: 351
Symposium S6: Additive manufacturing: challenges and solutions
Extended Abstract

Abstract

Laser powder bed fusion (L-PBF) has generated a lot of interest in the aerospace industry thanks to its capability to manufacture complex metal parts. However, in the case of aluminium alloys, the palette of materials remains limited for the L-PBF process. Indeed, the rapid cooling and the specific thermal history of L-PBF generate complex microstructures. Furthermore, for aerospace applications, in which the fatigue performance is crucial, a low porosity is necessary. In the case of Al7075, several issues have been listed with its processing by L-PBF. First, the alloy is susceptible to hot cracking due to its large solidification interval. Secondly, the high vapor pressure of some elements (mainly Zn and Mg) leads to a loss of alloying elements and the formation of porosity. To eliminate hot cracking, the most widespread solution is adding a grain refiner. Previous studies have demonstrated that Zr can effectively suppress hot cracking. The formation of Al3Zr precipitates at the beginning of the solidification generates nucleation sites and promotes a transition from a columnar grain growth to an equiaxed grain growth. Additionally, Al3Zr precipitates have a hardening effect. To reach its optimal mechanical properties, a conventional Al7075 requires a T6 heat treatment to form η and η' MgZn2 precipitates. In the case of Al7075+Zr alloys, both AlZr3 and MgZn2 precipitates can coexist. However, the identification of the precipitate distribution and the optimization of specific heat treatments, to reach their full potential, have not been widely studied in the literature. Therefore, the main objective of this study is, after identification of a tailored T6 heat treatment, to characterize the microstructure and the mechanical properties of a Zr-modified Al7075 alloys deposited by L-PBF. The powder used is based on an Al7075 alloy that has been modified with Zr and enriched with Mg and Zn before atomization. The powder was processed on a ProX DMP 200 printer. The microstructure and the mechanical properties of the material were characterized in the As Built (AB) and tailored T6 states. The porosity was characterized by X-ray micro-tomography, and the microstructure was analysed by optical microscopy and scanning electron microscopy (SEM). Both AB and T6 precipitation states were analysed by transmission electron microscopy (TEM) and by atomic probe tomography (APT). The modified Al7075 presents a bimodal microstructure, with coarse columnar grains and fine equiaxed grains. This type of microstructure is commonly observed in Al alloys modified with grain refiners in L-PBF. The tailored T6 heat treatment leads to an important increase of the yield strength (611 MPa +/- 8 MPa). Analysis of the microstructure by TEM and APT revealed that this outstanding yield strength was mainly attributed to the formation of Al3Zr L12 precipitates during the high temperature step of the heat treatment and MgZn2 during the low temperature stage of the heat treatment.

Keywords:

Al7075 L-PBF Tensile properties Tailored T6 Heat treatment Microstructure characterization