Healing damage in Almazium: a new high-strength aluminium alloy produced by additive manufacturing

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Abstract

Aluminium alloys produced by additive manufacturing are largely used in aerospace where damage may occur due to overloads experienced in service. A promising approach to avoid the replacement of damaged parts by new ones is to use a material able to heal its damage sites.

The aim of this research is to design a new high-strength healable Al alloy manufactured by Laser Powder Bed Fusion (LPBF). The high cooling rate inherent to LPBF results in a refined microstructure consisting of α-Al cells enclosed by a Mg-rich low melting point eutectic network acting as healing agent, similarly to biological vascular systems. After damage, a healing heat treatment (HHT) induces the melting of this healing agent eutectic phase, enabling it to flow inside the defects to seal and weld them through solidification. Alternatively, a Healing Heat and Pressure Treatment (HHPT) can be applied, in which the isostatic pressure closes the cavities while the temperature welds them similarly to HHT. To enhance the strength of the alloy while maintaining its healing capabilities, Zr is dispersed into this Al-Mg alloy and forms hardening precipitates, this new alloy is called ALMAZIUM. The healing capacity of this new alloy is characterized by in-situ heating and in-situ tension under synchrotron X-ray nano-holo-tomography performed at line 16B of Grenoble (ESRF).

The same strategy has recently been adopted to manufacture this alloy by friction stir additive manufacturing with a characterization of damage healing performed by transmission electron microscopy and synchrotron X-ray nano-holo-tomography.