Extended Abstract

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Effect of different building direction on fracture toughness of ultra-high strength aerospace components made by additive manufacturing

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Abstract:

Direct metal laser sintering (DMLS) and selective laser melting (SLM) are an additive manufacturing (AM) technique that produces complex three-dimensional parts by adding layer upon layer of powder materials from bottom to top. Recently, AM has received large amount of press and is set to have a large impact such as decreasing the cost of production, fast and flexible, design freedom, increase the innovation opportunities and develop new materials system for the consumption of Aerospace industries. Since major problems come across, the process is limited to surface quality, and residual porosity in SLM and DMLS parts may be undesirable for some applications where fatigue resistance and high strength are essential. This research aims to improve the fracture toughness, ductility and fatigue life for the metallic components, which is essential to entirely exploit potential of the SLM and DMLS of these alloys for Aerospace applications. The development in the additive manufacturing technology is not only limited to new machines and new materials and methods but also new processes, to offer high mechanical properties and performance. This research focus on DMLS and SLM of titanium and stainless steel alloys to investigate the effect of different building direction on strength, ductility and fracture toughness property. This investigation may create a strong need for a system that could contribution in the selection of the possible process chains, materials and finishing options and may extend the capability of AM process to generate high performance component for commercial application in Aerospace industries. Experimental investigation was conducted to evaluate the fracture toughness and fatigue crack growth characteristics in selective laser-melted titanium 6Al-4 V materials as a follow-on to a previous study on high cycle fatigue. For both the fracture toughness and crack growth evaluation, the compact tension specimen geometry was used. It was found that the fracture toughness was lower than what would be expected from wrought or cast product forms in the same alloy. This was attributed to the rapidly cooled, martensitic microstructure, developed in the parts. At low stress ratios, the crack growth rates were faster than in wrought titanium but became comparable at higher ratios. The fracture toughness appears to be higher when the crack is oriented perpendicular to the build layers. The difference in the average threshold and critical stress intensity values for the crack growth results for the three orientations was within the scatter of the data, so there was essentially no difference. The same was true for the empirically derived Paris Law constants. Residual stresses were likely to have overshadowed any variation in crack growth because of microstructural directionalities associated with build orientation. The purpose of this paper is to study new process parameters which were selected to achieve the full density of Ti-6Al-4V samples in different building orientations and investigate fracture toughness property and its relation to the microstructure, an area which has not previously been reported in full detail and which may offer information to a designer. Direct metal laser sintering (DMLS) is an additive manufacturing technique that directly manufactures three-dimensional parts, layer-by-layer, to scan and melt metal powders for aerospace applications

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