Alloy design for additive manufacturing of a 6xxx aluminum alloy for ultra-high and medium strength applications

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**Keywords:** LPBF, Mechanical Properties, Single tracks, Hot cracking sensitivity, FEM, EBSD

**Abstract**

6xxx alloys are widely used in different industries, such as automotive and aerospace industries. However, one of the main limitations for laser powder-bed fusion (LPBF) of this group of aluminum alloys is high hot cracking sensitivity. LPBF processing of 6xxx alloys parts without cracking is challenging. Often, hot cracking resistant LPBF alloys contain an extensive amount of Sc or Zr, which are expensive elements.

In this work, crack susceptibility models are used to develop a hot crack resistant Al-Si-Mg alloy with reduced Zr content. The observation of single laser tracks on plates machined from as-cast ingots, allows to preselect candidate alloys that show no cracks. Then, finite element modeling is used to simulate different processing parameter sets and extract the values of thermal gradient and solidification rate. These values are required to calculate the hot cracking sensitivity index (HCS). Results showed that the thermal gradient is relatively independent of composition. However, for the solidification rate, the influence of composition is larger. For six alloys that did not have any cracks, the hot cracking sensitivity was calculated, and the alloy with the lowest HCS was selected for gas atomization and further processing. Printed parts with a density higher than 99.5% are obtained. No cracks are observed in samples printed with the optimized parameters. A proper choice of laser scan parameters results in an optimal bi-modal structure of melting pools consisting of columnar and equiaxed grains. Different heat treatments are used to adjust the required mechanical properties that can fit high and medium-strength applications.