The role of dendrite growth and cooling rates in the densification mechanism of L-PBF of AlSi10Mg alloy

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The typical microstructure of AlSi10Mg laser powder-bed-fusion (L-PBF) components contains aluminum dendrites between a Si based eutectic. There is a broad distribution of dendrite sizes between the centre and edge of each melt pool deposited which develop due to different local cooling rates in these regions. However, the majority of dendrites in the melt pool centre are oriented with primary dendrite arms parallel to the build direction. This allows primary dendrite arm spacing (PDAS) to be measured consistently between melt pools and components. In the present investigation AlSi10Mg was processed using a 1kW pulsed-mode laser and using process parameters that proved to result in L-PBF AlSi10Mg components with density ranging from ~ 98.1 - 99.9 % measured by optical microscope from cross-section micrographs. The microstructures of components produced using the L-PBF process were analysed and average PDASs were statistically measured using image processing of representative micrographs. A correlation between average PDAS and part density was observed when varying exposure time and hatch spacing were used to manufacture the components. No lack of fusion flaws were detected. The literature shows an inverse correlation between dendrite size and cooling rates [1]. In this study the potential for an inverse correlation between part density and PDAS is explored. A finite element model, previously used to predict lack of fusion in L-PBF components [2], was adapted to simulate cooling rates in L-PBF of AlSi10Mg. The cooling rate predictions of the model are correlated with PDAS and density measurements resulting from the range of process parameters selected.

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[2] T. London, D. De Bono, V. Oancea, S. Tripathy (2017) Predicting the Properties of Additively Manufactured Parts, TWI Ltd.