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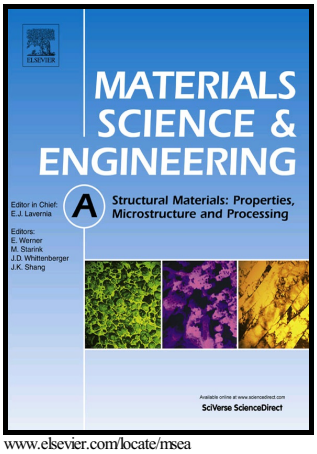

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Processing optimisation, mechanical properties and microstructural evolution during selective laser melting of Cu-15Sn high-tin bronze

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Abstract

Selective laser melting (SLM), as a novel additive manufacturing technique, has attracted increasing attention in copper alloys. In this research, to investigate forming processing and attendant mechanical properties of high-tin bronze in SLM, a statistical relationship between processing parameters (laser power, scanning speed and hatch space) and density of Cu-15Sn bronze in SLM was established using an experimental approach with response surface method and analysis of variance. As such, nearly fully-dense SLM Cu-15Sn bronze specimens were firstly manufactured whose reasonable microstructural evolution and mechanical properties were investigated before and after annealing and compared with QSn15-1-1 (GB/T 5231-2012) drawing specimens. It is found that the SLM Cu-15Sn specimens present the significantly fine grain microstructures that consist of cellular and dendritic structures. The ultimate tensile strength varies from ~661 MPa to ~545 MPa, the elongation at break from ~7.4% to ＞20% and the Vickers hardness ranges from ~212 HV 0.3 to ~168 HV 0.3 for SLM Cu-15Sn specimens after annealing, which are generally superior to those of QSn15-1-1 specimens. In addition, it has been proposed that the dominated strengthening mechanism of SLM Cu-15Sn parts has transformed from fine-grain to solid solution strengthening after annealing.

Keywords: Selective laser melting, copper alloys, microstructure, crystal growth, mechanical properties

1. Introduction

Tin-bronze, mainly including Cu and Sn elements, is one of the oldest traditional alloys known to people. The diversities in properties of tin bronze are owing to the different tin content, resulting in a wide range of applications [1]. In general, tin bronze with low level Sn (less than 5 wt.%) intended for plastic working is widely used in electrical and electronic industries such as sensitive elements of pressure gauges and electrical connectors as well as high-precision springs [2, 3]. With the increase of the content of tin, the mechanical properties of tin bronze can be strengthened [4]. When tin content is greater than 10 wt.%, high-tin bronze exhibits excellent mechanical properties