Changes in microstructure and behaviour of additively manufactured AlSi10Mg alloy induced by elevated temperatures

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Because of the high demand for lightweight metallic structures, the additive manufacture (AM) of aluminium alloys is being increasingly considered. In particular, the automotive and aerospace industries take advantage of the geometric freedom offered by AM to produce complex parts, e.g. in their engines. Because such parts can be exposed to elevated temperatures during operation, material stability is very important, but as yet little is known about it in relation to AM. Therefore, our study aimed at verifying whether the AlSi10Mg alloy is stable when processed by AM and exposed to elevated temperatures (above 373 K). Specimens of the AlSi10Mg alloy were produced by the selective laser melting (SLM) technology and their microstructure and mechanical properties were characterized. Afterwards, four sets of samples were subjected to temperatures between 393 and 453 K. Hardness evolution was measured for each temperature and an increasing trend was observed generally, suggesting some microstructural changes. The maximum hardness state obtained at 433 K was selected for further studies comprising microstructural analysis by scanning and transmission electron microscopy (SEM, TEM), chemical composition analysis and assessment of mechanical properties in tension. Although no microstructural changes were detected in the magnification range of SEM, TEM revealed nano-scale acicular precipitates being the cause of a slight increase in the yield strength of the alloy connected with a significant drop in elongation. Electron energy loss spectroscopy (EELS) and energy dispersive spectroscopy (EDS) proved pure Si forming the precipitates. To stabilize the microstructure, two regimes of heat treatment (stress-relief and T6) were applied. Changes in hardness were no longer observed but mechanical properties dropped significantly. Our results thus suggest that for applications with possible occurrence of elevated temperatures, an appropriate heat treatment should follow the AM of the AlSi10Mg alloy.

Authors wish to thank the Czech Science Foundation (project no. P108/12/G043) for the financial support of this research.