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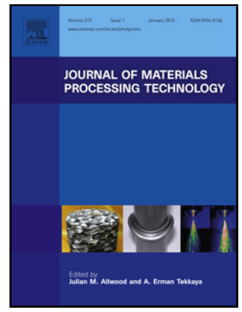

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Hot workability and microstructure evolution of pre-forms for forgings produced by additive manufacturing

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Abstract

Additive Manufacturing (AM) processes allow for near-net shape production of components without dies or substantial machining. Especially for energy-intensive materials, AM processes offer a reduction in lead-time, and in some cases also of yield loss and cost. However, the properties and microstructure of the parts fabricated by AM will not reach the level of forged material without using expensive downstream processes such as hot-isostatic pressing. Using the specific advantages of both processes, AM could be combined with forging operations to novel process chains, offering the possibility to reduce the number of forging steps and to create near-net shape forgings with desired local properties. The present study focusses on the investigation of the microstructure evolution during heat treatment and hot working of Ti–6Al–4V specimens which were produced by means of selective laser melting (SLM). The results show that the as-built SLM samples are well hot workable and have a lower activation energy for hot working, lower peak stresses as well as faster the globularization kinetics than conventional wrought material with a lamellar microstructure. These properties can be also considered favourable for hot working and may be exploited to reduce the tool load during forging.

Keywords: Additive manufacturing; hot forging; microstructure; hot working behavior.

1. Introduction

The production of components made of titanium alloys is of great importance for the transport and energy sector as well as for medical applications. The appropriate selection of a suitable manufacturing technique for a specific part depends on geometrical complexity, production quantity and cost. According to these issues different manufacturing processes offer specific advantages and disadvantages. Semiatin et al. (1997) analyze the effort involved in hot forging of titanium alloys. The forging process often requires expensive dies, multiple forming steps and leads to forged parts with tolerances that require extensive machining operations to create the final shape and a large amount of scrap. As