Optimizing the Heat Treatment Parameters of Additively Manufactured IN718 Components

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Abstract

Ni-based superalloys have gained importance in aerospace and energy industries due to their excellent mechanical properties at elevated temperatures. Conventional manufacturing methods such as casting and forging create defects having adverse effects on the service performance. Moreover, microstructures of cast and wrought products contain brittle phases, which negatively affect the machinability. In recent years, additive manufacturing techniques have been developed for production of Ni-based superalloy components having extremely complex shapes and/or functionally graded layers. This study focusses on optimization of the heat treatment procedure for the IN718 parts additively manufactured by selective laser melting. The relationships between microstructure and mechanical properties will also be investigated.

1. Introduction

For building complex shapes from IN718, traditional production methods are not preferred due its low machinability. Additive manufacturing (AM) has various advantages, such as easy manufacture of complex-shaped components, improved production-development cycle and cost-saving by optimizing material usage [1]. Selective Laser Melting (SLM) is usually preferred AM technique however it may create some problems due to residual stress, micro segregation, and existence of non-equilibrium phases. Heat treatment processes are required to control of microstructure and to achieve desired mechanical properties.

2. Materials and Methods

The specimens were produced from the gas atomized powder of IN718 by SLM with 40 µm layer thickness, 250 W laser power, 150 mm/s laser speed and hatch distance of 0.1 mm. The production parameters and building direction were kept constant to minimize their effects on mechanical properties. N_2(gas) was used to prohibit the oxidation of alloy elements during the production. The standard heat treatments, i.e. direct age (DA), solutionizing and direct age (STA), homogenization and STA were applied to the specimens. The microstructure, micro hardness and tensile properties of the specimens were investigated.

3. Conclusions

a) The microstructure of IN718 manufactured by SLM is remarkably different from those of as-cast and wrought conditions. Initial microstructure affects the phase transformation kinetics during heat treatments. Homogenization temperature of the specimen produced by SLM is higher than that of conventionally produced one.
b) Elongated grain morphology along the build direction and the melt pool boundaries are still observed after DA while they are not observed after STA. Partial precipitation of γ' and γ'' phases had occurred, and remaining Laves phase was observed after DA. However, STA provides fully developed precipitation of γ' and γ'' phases.
c) STA significantly improves hardness and tensile strength of the specimens in comparison to the as-processed ones.

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