Effect of Heat Treatment on Microstructure and Mechanical Properties of Additively Manufactured 18Ni300 Maraging Steels

İbrahim AYDIN[1], Aydın YAĞMUR[2], Süha TİRKEŞ[1], C. Hakan GÜR[1]
[1]Middle East Technical University, [2]EOS GmbH Electro Optical Systems
[1]Turkey, [2]Germany

Abstract

Recently, additive manufacturing of maraging steels has gained importance as an alternative to the traditional manufacturing techniques for aerospace components. In this study, various procedures were conducted to find optimum homogenization and aging treatment parameters for 18Ni300 parts that were additively manufactured via Selective Laser Melting (SLM).

1. Introduction

Production of engineering components having superior mechanical properties and high dimensional stability is very important, especially in aerospace and aircraft industries. Additive manufacturing (AM) has many advantages compared to traditional methods in terms of physical and mechanical properties; in some cases, also cost. Many studies related to the optimization of AM parameters and heat treatments have been done in AM of complex-shaped engineering components with desired properties. Due to the different microstructural features of the additively manufactured parts, optimization of heat treatment processes becomes a critical issue.

2. Materials and Methods

The specimens were additively manufactured from the gas atomized powder of 18Ni300 maraging steel via the SLM technique 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(g) was used in order to prohibit the oxidation of alloy elements during production. A series of heat treatments, including solution treatment, direct aging and solution + aging treatments have been conducted on the specimens. The specimens were aged at 490°C for different times to obtain the optimum aging time to achieve the desired microstructure and mechanical properties. All heat-treated specimens were quenched in air. The microstructure, micro-hardness and tensile properties were investigated.

3. Conclusions

(1) The parts manufactured by SLM have fine cellular structure and coarse grains. After aging treatment, the grain boundaries of the lath martensite become very blurry, and Ni, Mo and Ti dissolved in the matrix by forming tiny Ni_3Mo, Fe_2Mo and Ni_3Ti particles. Moreover, after solution treatment, the reverse transformation of martensite to austenite takes place and cellular structure disappears.
(2) Due to the disappearance of the cellular structure and the formation of precipitates, the mechanical properties change significantly with the heat treatment parameters. The hardness drops from 370 HV to 323 HV after solution treatment, whereas it rises to 614 HV after aging. The ultimate tensile strength drops from 1206 MPa to 920 MPa after solution treatment, whereas it increases significantly up to 2168 MPa after aging.

Acknowledgement: The authors gratefully appreciate to sample support from the EOS, Germany.

References

[1] ASM International, “Classification and Designation of Carbon and Low-Alloy Steels,” ASM Handbook, Vol. 1 Prop. Sel. Irons, Steels, High-Performance Alloy., vol. 1, no. c, pp. 140–149, 1990.

[2] E. Yasa, K. Kempen, J. P. Kruth, L. Thijs, and H. J. Van, “Microstructure and mechanical properties of maraging steel 300 after selective laser melting,” in *21st Annual International Solid Freeform Fabrication Symposium - An Additive Manufacturing Conference, SFF 2010*, 2010, pp. 383–396.