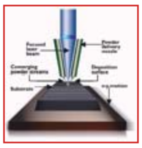
INFLUENCE OF HEAT TREATMENT ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF Ti-6Al-4V ALLOY PREPARED BY 3D PRINTING

Damian KALITA[1], Łukasz ROGAL[1], Marek St. WĘGLOWSKI[2], Jan DUTKIEWICZ[1], Tomasz DUREJKO[3], Tomasz CZUJKO[3]

[1] Institute of Metallurgy and Materials Science, Polish Academy of Sciences, Krakow, Reymonta 25, 30-059 Krakow, Poland
[2] Department of the Testing of Materials Weldability and Welded Construction, Institute of Welding, Bł. Czesława 16-18, 44-100 Gliwice, Poland
[3] Department of Advanced Materials and Technologies, Military University of Technology, Kaliskiego 2, 00-908 Warsaw, Poland

INTRODUCTION

Laser Engineered Net Shaping (LENS) is an additive manufacturing technology developed for fabricating near net-shape metal parts by using a metal powder injected into a molten pool created by a focused, high-powered laser beam.

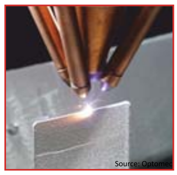


Additive manufacturing is gaining importance in the case of:

- Low production volumes
- High material cost and high machining cost
- Prototyping
- Logistics and transportation costs

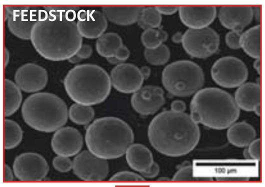
AIM OF THE WORK

The aim of this work was to analyse the influence of post processing heat treatment on the microstructure and mechanical properties of Ti-6Al-4V titanium alloy prepared by Laser Engineered Net Shaping 3D printing process.



EXPERIMENTAL

FEEDSTOCK



SAMPLE

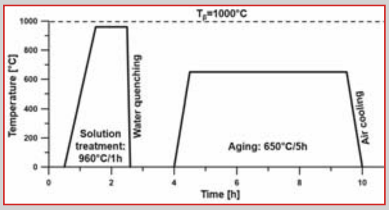
Material Fabrication

The deposition was performed using a LENS MR7 system with a 500 W fiber laser, which has a minimum beam diameter of 200 µm at a central emission wavelength of 1070 nm.

Manufacturing parameter	Value
Laser power	250 W
Deposition speed	16 mm/s
Layer thickness	50 µm
Material	Spherical powder 45-105 µm
Atmosphere	Argon

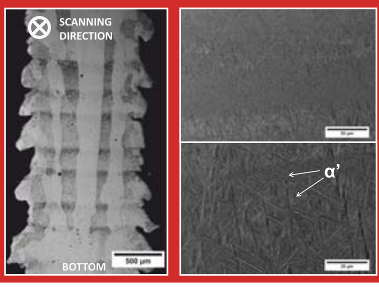
Heat Treatment

Heat treatment was performed in order to improve mechanical properties of the deposited materials, according to the scheme presented below.



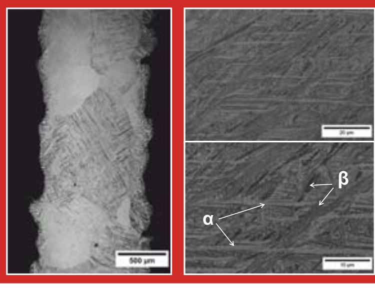
RESULTS

MICROSTRUCTURE OF THE AS-DEPOSITED MATERIAL



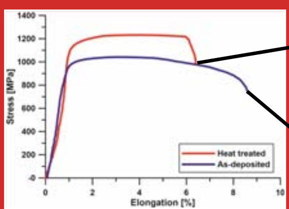
In the microstructure of the as-deposited material elongated (up to a few millimetres), primary β grains are present in the centre of the wall. Inside those grains, a fine, martesitic microstructure is observed.

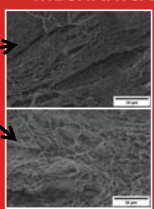
MICROSTRUCTURE OF THE HEAT TREATED MATERIAL



The heat treatment leads to extensive growth of primary β grains. Their morphology was changed from elongated to equiaxial. Inside those grains, fine, two-phase microstructure is observed.

MECHANICAL PROPERTIES

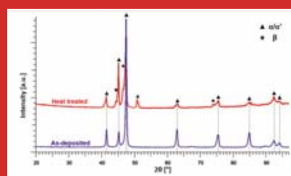




The fracture surfaces exhibiting ductile features.

	As-deposited	Heat treated	Reference
Yield strength [MPa]	906	1069	1020 – 1080
Tensile strength [MPa]	1042	1232	1100 – 1270
Elongation [%]	8,6	6,5	8 – 13
Hardness [HV]	371 ± 4	468 ± 8	380 – 420

PHASE COMPOSITION



Heat treatment leads to formation of two phase (α+β) microstructure.

ACKNOWLEDGMENTS

The research was co-financed by the European Union from resources of the European Social Fund (Project No.WND-POWR.03.02.00-00-I043/16).

EUROPEAN UNION
European Structural and Investment Fund

European Funds
Knowledge Education Development

CONCLUSIONS

- In the microstructure of the as-deposited material elongated, primary β grains are observed. High cooling rate, during the process, leads to the formation of martensitic microstructure inside those grains.
- Heat treatment leads to extensive growth of primary β grains. Inside those grains, fine, two-phase α+β microstructure is observed. The α phase occurs as fine laths, while the β phase occurs as small precipitation at laths boundaries.
- Heat treatment leads to an increase of yield strength and tensile strength of the material by about 20% in comparison to as-deposited material.

REFERENCES

Hofmeister, William, et al. "Investigating solidification with the laser-engineered net shaping (LENSTM) process." *Jom* 51.7 (1999): 1-6.
Hedges, Martin, and Neil Calder. "Near net shape rapid manufacture & repair by LENS." *Cost Effective Manufacture via Net-Shape Processing, Meeting Proceedings RTO-MP-AVT-139, Paper*. 13. (2006): 1-14.
CES EduPack 2011 Version 7.0.0, Cambridge, Granta Design Limited, 2011.

60. KONFERENCJA SPAWALNICZA MIĘDZYNARODOWA

16-18 października 2018 r. - Sosnowiec