Optimization of Heat Treatment and Surface Post-processing in the Development of Hybrid Additive manufactured Ti6Al4V Structures

Simon Malej
Institute of Metals and Technology, Lepi pot 11, SI-1000 Ljubljana,
E-mail: simon.malej@imt.si

An upgraded Hybrid AM technology allows better customisation of products, internal structures that would be impossible to produce by conventional manufacturing methods, it also enables the building of hollow structures and therefore reduces weight of the parts, which is crucial in aerospace industry. To improve the ductility, reduce thermal stresses and to achieve anticipated mechanical properties of Ti6Al4V AM manufactured products suitable heat treatments will be assessed.

Heat treatment procedure will be optimized in order to eliminate residual stresses, undesired martensitic structures in both AM regions and to gain required mechanical and corrosion properties. The standard heat treatments for bulk alloys are not optimal for AM processed parts and have to be adapted to achieve desirable properties of as-built part. The different response of SLM, DED and SLM/DED parts on generally applied heat treatments will be studied and the influence of time, temperature and cooling rate will be evaluated. Sub β-transus annealing (800 to 950 °C for 1 h or more) with furnace cooling (to prevent martensite formation) will be employed. Temperature and time will be modified in order to eliminate martensite ($\alpha' \rightarrow \alpha+\beta$), improve elongation at fracture and prevent huge drop in yield and tensile strength.

Appropriate discharge and plasma parameters will be determined for modification of AM printed Ti6Al4V. Radiofrequency oxygen and hydrogen plasma will be used at different input powers ranging from 200 to 800 W. Variations in pressures and treatment times will also be studied. Pressure will range from 20 to 100 Pa and the optimal pressure will be determined. After the pressure and power adjustment, the treatment time will be optimized as well. As the surface in oxygen plasma will be modified by fluxes of high energy electrons, low energy ions, excited species and long-lived metastable species of oxygen we expect to obtain surface with higher oxygen content and with thicker oxide layer. Effects of different plasma treatment conditions will be evaluated by surface sensitive analysing techniques as well as corrosion resistance study. After optimizing plasma treatment conditions, the uniformity of treatment will also be studied on AM printed parts. The main goal in this part would be to allow for uniform modification of parts with complex geometries.