METAL ADDITIVE MANUFACTURING: MATERIALS AND PROCESS OPTIMISATION

Ada Steponavičiūtė, Vitalija Jasulaitienė, Karolis Stravinskas, Genrik Mordas

Department of Laser Technologies, Center for Physical Sciences and Technology
e-mail: ada.steponaviciute@ftmc.lt

Additive manufacturing (AM) is a type of manufacturing technologies where the material is added a layer upon layer to produce a 3D object. Due to the flexibility of the technology, unique and geometrically complex parts can be produced from a wide range of materials such as various plastics, ceramics and metals [1]. Metal AM is considered to yield the highest strength of manufactured parts; thus, these parts can be successfully implemented in such industry sectors as space, aviation, automotive, etc. One of the most widely applied metal AM technologies, where, in a layer-by-layer fashion, bulk parts are created by selective sintering and consolidation of thin powder layers using a laser beam is called Direct Metal Laser Sintering (DMLS) [2]. DMLS is applied in the Department of Laser Technologies and is successfully utilised in cooperation with the Department of Characterisation of Materials Structure.

DMLS can help produce parts from various metals, but in order to achieve consistent and predictable properties and ensure high quality of 3D-printed objects, these materials shall possess specific characteristics. In this research, we studied initial properties of a cobalt-chrome-molybdenum–based superalloy powder by using sophisticated techniques such as the scanning electron microscopy (SEM) with an energy-dispersive X-ray spectrometer (EDS), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES) and particle-induced X-ray emission (PIXE). The summarised results have shown dispersion of main components (Co, Cr, Mo), an attenuating of $Co_{0.64}Cr_{0.32}Mo_{0.04}$ with $Co_{0.9}Mo_{0.1}$ phase, and differences in size, shape, surface roughness, structure and content of S, C, Mn and Si among individual particles. Depending on the particle surface structure, differences in the oxidation of particles have been found. According to Auger survey spectra, the smallest particles had a low concentration of Co and Cr oxides, while the smooth ones had higher contents of metal oxides.

However, to achieve high quality prints, knowing the chosen material is not enough and process optimisation is required. Therefore, we investigated the influence of laser power and laser scanning speed on mechanical properties of materials and microstructure and experimental results had shown that laser energy density values between 50-60 J/mm^3 yielded the best results. However, the optimum energy density value was different for different properties (e.g. strength and surface roughness).

References

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