MATERIALS SCIENCE AND TECHNOLOGY

AMMIN - Development of high-performance Ni-based superalloys by Additive Manufacturing processes

Funded By	Politecnico di TORINO [P.iva/CF:00518460019]
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Context of the research activity	There is a growing interest in the development of new Ni-based superalloys through Laser Powder Bed fusion (L-PBF) and Electron Beam Powder Bed fusion (EB-PBF), which are two promising Additive Manufacturing (AM) processes. To date, there is a need to develop new high-performance Ni-based superalloys characterized by high quantity of ¿' phase formining elements like Al and Ti. In fact, these Ni-based superalloys offer outstanding mechanical performance at high temperatures coupled with high oxidation resistance. However, the high concentration of these chemical elements drastically reduce its weldability and processability by means of AM technologies. Another strategy is related to the chemical modification of the alloy with the addition of a reinforced phase like ceramic particles in order to improve the mechanical performance, but it is essential to optimize the process paramers to obtain dense components. The aim of this research is to develop innovative Ni-based superalloys, starting from process parameters, to generate dense components and then study the post-heat treatments that improve their mechanical performances. At the Politecnico di Torino, both L-PBF and EB-PBF, as well as several furnaces, are available, and we aim to utilize them to optimize process parameters and to design the microstructure, thereby developing new high-performance Ni-based superalloys.
	The aim of this work is to optimize the process parameters through L-PBF and EB-PBF, followed by heat treatments, in order to develop original Ni-based superalloys. Several parameters must be investigated, such as the power of the heating source (laser or the electron beam), the temperature of preheating, and the scanning strategy, thus requiring an in-depth understanding of them in order to minimize the residual defects like porosities and possible microcracks occurring for Ni-based superalloys with a high concentration of ¿' phase forming elements (Al and Ti). For the Ni-based susperalloy with high Al and Ti, the correct preheating temperature can help to inihibit the cracks formation, obtaining high-performnance Ni-based superalloy with a high densification

Objectives	level. Innovative strategies can be applied to design the grain growth, such as chemical composition modification like the addition of ceramic particles to reduce the grain growth and increase the microstructure stability at high temperatures or to use the novel point melt strategy to obtain equiaxed grains due to a different thermal history during the melting stage compared to standard line melt strategies. Finally, it is also essential to investigate subsequent heat treatments to enhance the mechanical properties for the intended application. The first type of material that the PhD student will be required to deal with is Inconel 939, to be produced by EB-PBF, and Inconel 625 alloy reinforced with ceramic particles using the L-PBF process. Optical microscopy, SEM-FESEM coupled with EDS and EBSD detectors, X-ray diffraction, microhardness, hardness testing, tensile tests, and thermal analysis will be among the primary characterizations.

Skills and competencies for the development of the activity	Skills and competencies in the preparation and characterization of metallic materials, as well as the correlation of microstructures and mechanical properties of metallic materials. Knowledge about the additive manufacturing process for the production of metallic materials, focusing on Ni-based superalloys.