POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

PNRR 117 Research Field: DESIGN FOR ADDITIVE MANUFACTURING RULES FOR FUNCTIONAL AEROSPACE STRUCTURES

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Additive manufacturing (AM) allows a high level of design freedom to produce complex components impossible to manufacture by traditional technologies. A set of guidelines and a structured framework are necessary to maximise the quality of parts produced by AM. These are conventionally named Design for Additive Manufacturing (DfAM) guidelines and focus on the printing steps of a part, be it during its design and conceptualization stage, the printing process itself including support structures, or the post-processing procedures (e.g., support removal and heat treatments). Although AM has many advantages compared to machining, it has some drawbacks that require specific process-related DfAM. This PhD project aims to develop a robust design process for aerospace functional parts considering all manufacturing aspects and reducing the overall impact of post-postprocessing on the final component.
Methods and techniques that will be developed and used to carry out the research	DfAM constraints can be subdivided into so-called directional and non-directional categories. The print direction directly influences the first set and includes anisotropy, support structures design and optimization, and the presence of distortion and residual stresses. The non-directional constraints are not influenced by the build direction and include power enclosure and feature size control. To achieve a more complete implementation of the DfAM guidelines, all constraints should be considered and implemented during the topology optimization

	and implemented during the topology optimization designing phase. Considering Powder Bed technologies, the two main drawbacks are higher surface roughness and dimensional inaccuracy of as-built part surfaces particularly in overhang features. Support structures are one of the solutions to mitigate these drawbacks at the cost of additional printed materials and post-processing efforts. Indeed, to enable manufacturability in laser powder bed fusion process, the support structure is one of the main elements. Generally, if a part surface has an inclination below 45° with respect to the build plate, it needs to be supported. Above this angle, the surfaces are self-supporting, thus no need for extra support structures. The design and location of support structures are also important for the resulting surface quality and dimensional accuracy. Inappropriate support designs may result in higher surface roughness and even build failures when these structures are physically removed after manufacturing. At the current stage, a general design process that included topology optimization of the part supports design and process simulation to predict residual stress and part distortion is a research matter and not systematically applied at the industrial level. In this view, an optimal design of the components including process simulation and support design is required and needs to consider: •Study of the effect of different support geometries on the mechanical properties of overhang metal parts manufactured by Selective Laser Melting technology. •Simulation of the manufacturing process using commercial Finite Element software including optimal support structures •Development of a design methodology concerning topology and shape optimization coupled with process simulation.
Educational objectives	During the 3-years education, the candidate will become familiar with all the aspects related to the design of aerospace parts for AM production. The research will provide the opportunity to achieve high-level skills in the

	areas of aerospace component design, numerical modelling and optimization techniques.
Job opportunities	The PhD graduate will have high-quality theoretical and technological expertise in the field of additive manufacturing for aerospace applications. The competencies acquired during the research will be appealing for manufacturers of aerospace parts as well as for aerospace companies.
Composition of the research group	2 Full Professors 1 Associated Professors 1 Assistant Professors 8 PhD Students
Name of the research directors	Prof. Antonio Mattia Grande

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Leonardo S.p.A.
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	PIEP (PT)
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
The PhD candidate will receive a desk, possibly through a hot-desking procedure, and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses and receive economic support to attend summer schools

and participate in conferences. There will be the possibility of paid teaching assistantship.