POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

PNRR 117 Research Field: LONG-TERM PERFORMANCE OF THERMOPLASTIC COMPOSITES

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	Thermoplastic polymers and composites offer several advantages over conventional thermosetting resins such as epoxies. Thermoplastics exhibit chemical and impact resistance and may be used over a wide range of temperatures. They have a very low level of moisture uptake, which means their mechanical properties are less degraded under hot/wet conditions. Furthermore, thermoplastic composite materials are reprocessable, repairable, and reformable, which together provide ease of fabrication, cost-effectiveness, and recyclability. Aerospace structures can take advantage of new thermoplastic materials that made possible the adoption of innovative processes and design allowing highly automated assembly technologies and more sustainable aerospace structures. On the other hand, little data are available for their long-term performances and thus, a large use in the aerospace sector is still hindered. A wide range of advanced thermoplastics are available and in common use today. In the area of high-performance thermoplastics for aerospace, polyketones (PEEK, PEKK, PAEK) and polyphenylenesulfide (PPS) are probably the most widely reported thermoplastic matrix and they will be considered in the PhD project. In this view, in three years, this PhD project is aiming to investigate the effects of manufacturing defects and damages, as in-service ones, on the long-term performances of selected thermoplastics composites, including possible maintenance design strategies and modelling aspects.

Methods and techniques that will be developed and used to carry out the research	The work will range by testing unconditioned and conditioned (humidity, impacts) thermoplastic composite specimens. Next to the already standard characterization and analytical techniques, e.g., ASTM standards for static and fatigue testing, the PhD will focus on fracture mechanics test methods to quantify long-term performances in conditioned and damaged interfaces, leading to an enhanced understanding of the ageing processes in these materials. Characterization of the materials and quantification of degradation and damage levels will be carried out in parallel during the entire project duration. Structure-property relations from model thermoplastic materials will evolve for macroscopic evaluation methods and performance tests under working conditions. The knowledge transfer from the model system to real thermoplastic composite is guaranteed due to the matrix chemistry independence. Experimental activities on conditioned specimens will be carried out with the main purpose of gathering information on the final mechanical behaviour of the considered thermoplastic materials, to either set limitations or derive general rules and design guidelines for better structural and functional performances to be transferred on component/assembly level. Relevant properties of thermoplastic composite materials such as stiffness, strength, fatigue resistance and fracture toughness will be evaluated on specimens and elements levels and a constitutive equation for the material will be developed for the study of primary aerospace structure. To transfer on structural detail level the properties of conditioned materials and linked numerical model, based on the knowledge and the experiences of defects, we will develop large structure sizing rules considering defect evolution. 3D model definition of a demonstrator large part (to be selected and developed in collaboration with Leonardo Helicopter division) based on a preliminary evaluation, the definition of panel sizing, dimensions and stress-based experience will be generated using CAD software. Preliminary stress sizing based on long-term material performances and based on a defect typology will be developed within the company by the PhD researcher. The analysis will be

	done with FEM software and the simulation will take into consideration also the real structure dimensions, pressure, loads, aerodynamic loads and temperature conditions.
Educational objectives	During the 3-year education, the candidate will become familiar with all the aspects related to the development, production, and characterization of innovative thermoplastic composites. The research will provide the opportunity to achieve high-level skills in the areas of experimental techniques, numerical modelling and the structural design of thermoplastic aerospace composite parts. In particular, the researcher will acquire a deep knowledge in the field of thermoplastic composite structures manufacturing, including state-of-the-art procedures for production, and comprehension of the chemical and physical phenomena in the processing cycles affecting material performances.
Job opportunities	The PhD graduate will have high-quality theoretical and technological expertise in the field of innovative high-performance thermoplastic composites for aerospace applications. The competencies acquired during the research will be appealing to manufacturers of composite parts for the aerospace, automotive, marine and civil fields, which require highly skilled engineers having the capability to understand and manage the manufacturing process of thermoplastics composites as well as the knowledge of their mechanical properties.
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)	TU Delft (NL)
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.