POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

THEMATIC Research Field: BINDER JETTING OF COMPOSITE MATERIALS WITH TAILORED MAGNETIC AND PHYSICAL PROPERTIES

Monthly net income of PhDscholarship (max 36 months)
1500.0 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) via binder jetting offers unique opportunities for producing complex components from a wide range of materials, including metals, ceramics, and their composites. This PhD project will focus on the design, processing, and characterization of composite materials fabricated by binder jetting, integrating phases with contrasting or complementary properties, as combinations of soft and hard magnetic materials, or non-magnetic matrices with phases conferring thermal, electrical, mechanical, or chemical functionality. The research will address the scientific and technological challenges related to the co-processing of dissimilar phases with different sintering kinetics, wetting behaviour, and thermal expansion coefficients. Emphasis will be placed on controlling microstructural interfaces, phase distribution, and residual stresses to tailor the final multifunctional performance of the printed parts. Strategies may include the optimization of powder blends, binder formulations, printing parameters, and post-processing treatments such as sintering, infiltration, or reactive diffusion. From an industrial perspective, this research responds to a growing demand for customizable, high-performance functional materials in fields such as electromobility, renewable energy, and high-efficiency electric machines,

	where integrated magnetic composites could enable compact and energy-efficient designs. Moreover, combining magnetic and non-magnetic materials or embedding phases with high thermal conductivity, wear resistance, or ductility, could open new routes for multifunctional components used in aerospace, automotive, and power electronics sectors.The main objectives of the PhD will be to: 1. Develop printable composite powder systems combining phases with tailored magnetic or physical properties. 2. Establish processing–microstructure–property relationships for binder-jetted composites. 3. Demonstrate functional prototypes (e.g., graded magnetic structures, magneto-thermal components, or wear-resistant magnetic composites) relevant to industrial applications. This project thus aims to bridge materials science, process engineering, and industrial design, contributing to the next generation of additively manufactured multifunctional components.
Methods and techniques that will be developed and used to carry out the research	The PhD project will combine experimental materials development, additive manufacturing process optimization, and advanced characterization to establish structure–property relationships in binder-jetted composite systems. The candidate will exploit the comprehensive facilities available at the Department of Mechanical Engineering of Politecnico di Milano, integrating them with resources from collaborating research centres and industrial partners. Powder and feedstock preparation includes the employment of laboratory mixers, attritors, and ball mills for homogeneous mixing of soft/hard magnetic or non-magnetic phases and it might rely on surface treatments and coatings via mechanical alloying, sol–gel, or wet chemical routes to improve interfacial compatibility and sintering behaviour. Binder Jetting development relies on the use of the ExOne Innovent+ or equivalent binder jetting systems available in the department, with

	optimization of layer thickness, binder saturation, and curing parameters. Thermal post-processing is performed under controlled atmosphere furnaces (air, inert, or reducing). Advanced characterization techniques, including optical microscopy, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), X-ray diffraction (XRD), and thermogravimetric analysis (TGA), will be employed to investigate the nature and distribution of phases within the multi-material system. These analyses will provide essential data for understanding interfacial characteristics and ensuring the electrical continuity of composite materials. The experimental work is aided by modelling of the material properties and processing via numerical simulations and CALPHAD-based thermodynamic, aided by statistical tools and machine learning approaches to correlate binder jetting parameters with final composite properties.
Educational objectives	At the end of the PhD program, the candidate will be able to define, design, and carry out original research projects, both independently and as part of a team, or by leading a research group in the field of advanced materials. Opportunities will be offered to undertake visiting research periods hosted by project partners, fostering international scientific collaboration.
Job opportunities	Job opportunities are expected both in national and international academic institutions, as well as in high-tech companies and SMEs focused on innovation and technological development. Our latest survey on MeccPhD graduates reported a 100% employment rate within the first year and an average salary 35% higher than that of Master of Science holders in the same field. During the PhD, the candidate will collaborate with European companies, universities, and public agencies, gaining valuable experience in multidisciplinary and international research environments

Composition of the research group	1 Full Professors 5 Associated Professors 4 Assistant Professors 5 PhD Students
Name of the research directors	Prof.ssa Nora Lecis

Contacts
nora.lecis@polimi.it For questions about scholarship/support: phd-dmec@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Financial aid is available for all PhD candidates (purchase of study books and materials, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of € 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 750 euro/month- net amount). Additionally, PhD candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3,000 to cover travel expenses. Teaching assistantship: availability of funding in recognition of supporting teaching activitiesby the PhD candidate. There are various forms of financial aid for activities of support to theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.