



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

Number of scholarship offered	5
Department	DIPARTIMENTO DI MECCANICA

Description of the PhD Programme

The Doctoral Programme in Mechanical Engineering of Politecnico di Milano offers top-level knowledge in one of the most profitable sectors in Italy and worldwide; it is a key instrument to access leading enterprises and to achieve prominent positions in large international companies devoted to research and development, innovation and design. The primary employment market is composed of leading companies and organizations dedicated to innovation, research and technical development, high-tech SMEs and governmental departments.

The research topics of our Programme fall in the category *Mechanical, Aeronautical & Manufacturing Engineering* of the *QS World University Rankings*, where Politecnico di Milano currently ranks 7th in the world (*QS Rankings by Subject 2023*).

The Programme covers a number of different disciplines, being devoted, in particular, to innovation and experimental activities. It relies on the development of an interdisciplinary and integrated high-level educational offer, by focusing on a comprehensive scientific proposal, from conception to realization; the core of our research lines falls within the societal trends identified at international and national levels: sustainable transport, health and wellbeing, clean energy, innovation and job creation. We also have ongoing collaborations with national and international most renowned research groups and laboratories.

Within our Programme all Doctoral Candidates follow a minimum path of three-years, which includes specific courses and lectures, held by Faculty members and foreign professors and experts: in particular, our candidates have access to a series of research seminars delivered monthly by international top-level faculty (*MeccPhD Lectures*) and to full courses provided by European and non-European academic experts. They also experience in-depth research, lab activities and active cooperation with international industries, institutions and research groups. With this background, our Doctorates are able to blend the soundness of scientific knowledge with the ability to deal with management and industrial issues. In this view, their scientific profiles are suitable for prestigious positions at national and international level within universities and research institutions, large industrial and consulting companies, SMEs.



Further information on our Doctoral Programme and on the Department of Mechanical Engineering of Politecnico di Milano may be found at the following link: <https://www.mecc.polimi.it/en/>.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: ACTIVE PANTOGRAPH AND NEW METHODOLOGIES FOR
PANTOGRAPH LAB TESTING AND VALIDATION**

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	<p>Pantograph-catenary interaction is one of the limiting factors for interoperability among different countries and for the speed-up of railway systems. The introduction of active pantograph control is considered as a possible source of improvement, giving the possibility to improve/optimize the dynamic interaction in different operating conditions. On the other hand the field testing of existing or new pantograph (passive or active) is usually costly and time consuming, therefore there is a strong interest by manufacturers and railway operators to reduce the field tests and perform at least part of the pantograph acceptance and homologation to laboratory tests or simulation with validated.</p>
Methods and techniques that will be developed and used to carry out the research	<p>The research will focus on the development of active solutions for the optimization of pantograph dynamics and of new methodologies for laboratory testing, for both active and passive pantograph. Numerical tools will be adopted for preliminary design and evaluation of the pantograph active system. An active pantograph prototype will then be realized and tested. Considering laboratory testing, both Hardware-in-the-Loop methodologies and identification/validation techniques based on imposed and fixed excitation will be developed and exploited.</p>
Educational objectives	<p>The candidate will acquire high-profile skills and will be</p>



	<p>dealing with both theoretical and experimental methodologies.</p> <p>He/she will develop knowledge in the following areas:</p> <ul style="list-style-type: none"> - analysis of complex dynamic systems with different methods and approach (numerical simulation, co-simulation of interacting virtual and physical components, experimental identification and validation) - analysis and optimisation of the performance of complex systems - technology and innovation in pantograph design and testing <p>Finally, the candidate will gain the capability of working and cooperating in a multidisciplinary team.</p>
<p>Job opportunities</p>	<p>Job opportunities may be found as: pantograph manufacturers, rail vehicle manufacturers, rail transport operators, railway infrastructure managers.</p> <p>Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/.</p> <p>The following Universities and companies will be cooperating in the research activity: University of Huddersfield, Universitat Politècnica de València, Contact, Hitachi Rail, Trenitalia, RFI.</p>
<p>Composition of the research group</p>	<p>2 Full Professors 2 Associated Professors 0 Assistant Professors 0 PhD Students</p>
<p>Name of the research directors</p>	<p>Prof. Alan Facchinetti</p>

Contacts
<p><i>Phone:</i> +39 02 2399 8450 <i>Email:</i> alan.facchinetti@polimi.it</p> <p>For further information/support, please contact phd-dmec@polimi.it.</p>

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	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, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 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).

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: ADVANCED MATERIALS AND SUSTAINABLE PROCESSES

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

The demand arising from technological innovations driven by the uptake of new manufacturing processes and improved product performance, is strongly motivating the development of innovative structural and functional materials with advanced and new properties.

Future materials need to be designed/optimized according to their specific processing route (e.g. materials for additive manufacturing), need to possess specific thermal and physical properties to fulfill special functions and could preferably show variation of their properties within the volume of a single components (e.g. multi-materials, gradient 3D lattices, metal-ceramic composites).

In addition, cost-effective and sustainable criteria need to be preferred for the selection of the of the alloying elements and the manufacturing route. The research field of advanced metallic materials is really vibrant, several research projects are available within this frame and perspective job opportunities are abundant.

Details about the specific topics to be faced during the PhD will be supplied on request.

Methods and techniques that will be developed and used to carry out the research

The Material research group has expertise on the design processing, microstructural and mechanical characterization of advanced metallic alloys.

The methods to be used will involve Thermodynamic



	<p>modelling of alloy microstructure, tools for experimental analyses on phase and microstructure analyses (optical and electron microscopy, EBSD, XRD, DSC,) and mechanical characterization among others by tensile testing, fracture toughness, fatigue testing, creep.</p> <p>For more details about available infrastructures, see: https://www.mecc.polimi.it/us/research/departmental-laboratories/.</p>
Educational objectives	<p>At the end of the PhD cycle the candidate will be able to define, design and carry out original research programs by working in a team or leading a research group in the field of advanced materials.</p>
Job opportunities	<p>Job opportunities are foreseen at national and international academic institutions, high-tech companies and SMEs involved in innovation and technical development, especially those already sharing research activities with the Materials groups at PoliMi.</p> <p>Employment statistics of PhDs can be found at https://cm.careerservice.polimi.it/en/employment-statistics/.</p>
Composition of the research group	<p>4 Full Professors 7 Associated Professors 2 Assistant Professors 10 PhD Students</p>
Name of the research directors	<p>Prof. Maurizio Vedani</p>

Contacts	
<p><i>E-mail:</i> maurizio.vedani@polimi.it <i>Phone:</i> 02 2399 8230 .</p> <p>For questions about scholarship/support, please contact phd-dmec@polimi.it.</p>	

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	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

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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 visiting periods abroad for up to 6 months (approx. 750 euro/month-net amount).

Funding for teaching assistantship is availability in recognition of supporting teaching activities by the PhD candidates. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: DIGITAL BIO-INSPIRED DESIGN AND BIOFABRICATION:
SUSTAINABLE STRATEGIES FOR ADAPTIVE BONE REPAIR**

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**

Bones exhibit a remarkable self-healing capability, however large-scale damage beyond a species-dependent critical size necessitates the incorporation of implants to guide the regeneration process. Every year, a few million bone-grafting procedures are performed; despite it being the gold standard for bone substitution, there are multiple challenges associated with the use of autologous bone grafts. These include limited bony stock availability, patient morbidity at the graft harvest site, and elevated major complication rates (8.6 - 17.9%) associated with additional surgeries for bone harvesting. Consequently, the demand for synthetic bone implants is substantial and anticipated to rise with the aging global population. For instance, the projected doubling of patients requiring bone implants due to osteoporotic fractures by 2040 underscores the growing need, fostering a global market for synthetic bone implants with an annual turnover surpassing 90 billion euros. The aim of the research is to design novel tailored sustainable solutions for designing new mini-invasive implants. The adopted multi-disciplinary strategy, combining high-level experimental and numerical approaches, will lead to:

- 1) the definition of **innovative clinician- and patient-oriented solutions for mini-invasively treating bone fragility**;
- 2) the **digital transition** of design strategies towards the definition of a new bone-inspired personalized scaffold



	<p>concept;</p> <p>3) a sustainable perspective in tackling bone fragility through the adoption of biodegradable solutions.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>This research requires a multi-faceted range of methods and techniques to investigate multi-scale damage phenomena and to translate this understanding to the design of novel structures, including:</p> <ol style="list-style-type: none"> 1. Imaging techniques: micro-computed tomography, synchrotron analyses, scanning electron microscopy are especially useful for identifying microstructural features that may contribute to a material resilience; 2. 3D printing and 3D bio-printing for complex structure design; 3. Multi-scale mechanical testing to study material mechanical properties, including its strength, toughness, and elasticity; 4. Computational modeling, to simulate damage evolution, weakening and toughening phenomena at the multi-scale, including extended finite element (XFEM) strategies to model fracture progression; 5. Image analysis, adopting effective artificial intelligence-based tools for the post-processing of large size datasets, such as high-resolution imaging.
<p>Educational objectives</p>	<p>This cutting-edge research perspective on tailored green solutions for bone repair is a unique opportunity for PhD students to:</p> <ol style="list-style-type: none"> 1. Elucidate the complexity of the multi-scale structure and characteristics of biological materials, as well as the fundamental principles governing their response to damage towards sustainable engineered solutions; 2. Employ a diverse array of methodologies and approaches, encompassing advanced imaging techniques, mechanical testing, and computational modeling, to investigate and analyze these materials; 3. Cultivate critical thinking and problem-solving abilities while nurturing innovation and creativity by providing guidance to doctoral students in the creation of novel bio-inspired structures that exhibit improved mechanical properties.



	4. Establish interdisciplinary collaboration among students and faculty from various disciplines, including biology, physics, mechanical engineering, and material engineering, to foster cross-pollination of ideas and expertise.
Job opportunities	<p>Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/ .</p> <p>Cooperating to this research are:</p> <ol style="list-style-type: none"> 1. IRCCS Ospedale Galeazzi, for a clinical perspective of the fragility problems; 2. TU Delft, with reference to bio-inspired material design; 3. Elettra synchrotron, for high-resolution real-time imaging of damage.
Composition of the research group	<p>1 Full Professors 0 Associated Professors 1 Assistant Professors 3 PhD Students</p>
Name of the research directors	Prof. Laura Maria Vergani

Contacts

Phone: +39 022399249 *Email:* laura.vergani@polimi.it

For questions about scholarship/support, please contact phd-dmec@polimi.it.

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	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

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Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: HUMAN-CENTRIC ENGINEERING DESIGN IN INDUSTRY 5.0

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	
<p>Motivation and objectives of the research in this field</p>	<p>On the one hand, Artificial Intelligence (AI) is radically changing the way data and information related to products and industrial processes are generated, acquired, elaborated and utilized. On the other hand, the role of humans in Industry 5.0 is of paramount importance, and new scenarios for exploiting human cognitive abilities are emerging. Given the apparent conflicting nature of the above trends, a research target that deserves significant attention is how to combine business and industrial interests with the valorization of human potential in the development of optimized products and processes. This research field concerns the methods and tools to properly exploit the implementation of digital technologies with the overall goal of developing advanced solutions and engineering design strategies. The specific research objective of the thesis will concern at least one of the following topics: Virtual, eXtended, and Augmented Reality, Metaverse, Digital Human Modeling, Artificial Intelligence (AI) for Design, Digital Twin and Additive Manufacturing.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The research will be developed by referring to both emerging and established methodologies and technologies such as: Virtual, eXtended and Augmented Reality, Reverse Engineering, Artificial Intelligence, Multi-objective Optimization, Digital Twin, Digital Data Management, Human-Human, Human-Computer and Human-Machine Interaction and Design for Additive Manufacturing.</p>



Educational objectives	Operational competencies on up-to-date methodologies and technologies for developing innovative digital solutions and applications. Capability to interpret technology evolution and the dynamics of technological and digital transformations. R&D skills for scientific and industrial applications. Soft skills in the delivery of scientific talks, drafting project reports and scientific papers, and delivery of presentations to industry.
Job opportunities	Employment statistics of PhDs can be found at https://cm.careerservice.polimi.it/en/employment-statistics/ . The PhD candidate will develop the PhD thesis within an international environment. The research group has multiple collaborations ongoing with Institutions and universities inside and outside Europe.
Composition of the research group	4 Full Professors 8 Associated Professors 4 Assistant Professors 19 PhD Students
Name of the research directors	Proff. Colombo, Cascini, Bordegoni, Ferrise

Contacts
<p>Names of the Research Directors:</p> <p>Prof. Giorgio Colombo (giorgio.colombo@polimi.it, +39 02 2399 8259) https://www.mecc.polimi.it/ricerca/personale-docente/prof-giorgio-colombo</p> <p>Prof. Gaetano Cascini (gaetano.cascini@polimi.it, +39 02 2399 8463) https://www.mecc.polimi.it/ricerca/personale-docente/prof-gaetano-cascini</p> <p>Prof. Francesco Ferrise (francesco.ferrise@polimi.it, +39 02 2399 8232) https://www.mecc.polimi.it/ricerca/personale-docente/prof-francesco-ferrise</p> <p>Prof. Monica Bordegoni (monica.bordegoni@polimi.it, +39 02 2399 8260) https://www.mecc.polimi.it/ricerca/personale-docente/profssa-monica-bordegoni</p> <p>For questions about scholarship/support, please contact phd-dmec@polimi.it.</p>

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)	--

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PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: HYDROGEN-BASED ELECTRIC ARC FURNACE DUST REDUCTION FOR ZN AND FE RECOVERY

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	Exploitation of hydrogen for the greening of Waelz process with the aim of a carbon neutral recover of Zn and Fe from EAF dusts.
Methods and techniques that will be developed and used to carry out the research	<ul style="list-style-type: none"> •Evaluation of the European steelmaking and ferrous foundry industries in terms of availability of Zn-containing dusts; •Characterization of Electric Arc Furnace dusts by chemical and crystallographic analysis; •Characterization of reduction products (ZnO, DRI and other by-products) by chemical, crystallographic and microstructural analysis; •Comparison between traditional and H₂-based Waelz process in terms of ZnO productivity, emissions, slag production and energy consumption.
Educational objectives	Improvement of the main skills in characterization of materials by in-depth application of analytical methods based on X-ray (XRF, XRD) and Optical emission (ICP, OES) spectroscopy; development of screening methodology for assessing the treatment feasibility of a specific dust for maximizing the yield of valuables extraction.
Job opportunities	The developed skills will be applied in several fields:



	<ul style="list-style-type: none"> • metallurgical industries; • steelmaking industries; • process modelling. <p>The research activities are embedded within the Horizon Europe project "Dust2Value - Pioneering Sustainable Recovery in Steelmaking: Hydrogen-Based Technology for Byproduct Management", G.A. 101138742, funded by the European Union.</p> <p>The research activities are conducted at the Department of Mechanical Engineering, Politecnico di Milano. Also cooperating in the research activities are: MontanUniversitat Leoben; Befesa Steel R&D; Mal Metallbau Anlagenservice - Leitungsbau GmbH; Georgsmarienhutte GmbH; InsSyro NV; Befesa Steel Services.</p>
Composition of the research group	1 Full Professors 5 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	Prof. Carlo Mapelli

Contacts
For questions about scholarship/support, please contact phd-dmec@polimi.it .

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	
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By number of months	6

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