POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: A NEW CUTTER-WORKPIECE ENGAGEMENT ALGORITHM FOR MULTI-AXIS MILLING

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	Chip removal processes involve some of the most complex phenomena in manufacturing. Modelling them is of valuable scientific and academic interest. Of all ways of modelling chip removal processes, Cutter-Workpiece Engagement (CWE) is the most promising and advanced. Algorithms of CWE can simulate the Swept Volume (SV) of the tool removing material from the workpiece. This is done by leveraging geometric kernels such as ACIS, Parasolid and OpenCascade. This allows users to be able to predict the cutting parameters associated with the cutting operation, which in turn allows for the calculation of important hallmarks of the chip removal process such as cutting forces. All simulators incorporate CWE algorithms which are most often based on Z-Level buffer, the oldest method of all (1972), reliable but also imprecise and slow. The objectives in this field therefore are multiple: 1. Establish which kind of method allows for the best trade-off between accuracy and robustness during simulation 2. Determine which is the best geometric kernel for the task considering all constraints 3. Design of a universal interpolator which is robust, fast and capable, as faithfully as possible, to calculate cutting time and represent toolpath 4. Development of a CWE method which is robust precise and fast, building on top of the best solutions

	precise and fast, building on top of the best solutions found in literature
Methods and techniques that will be developed and used to carry out the research	The research will leverage the most advanced instrumentations in this field. A Yasda YMC650+RT20, one of the most precise milling machines in the world, will be used to carry out tests. State of the art CAM software to produce part programs allowing thorough tests of the CWE engagement algorithm. VERICUT a state-of-the-art simulator of chip removal processes and more to benchmark the developed algorithm. The best programming software available such as Python, in order to interact with geometric kernels as seen necessary.
Educational objectives	The PhD candidate is expected to develop high level technical skills in the field of research previously mentioned. The candidate will need to operate independently both manufacturing and materials characterization equipment. Design of experiments techniques will be developed to conduct empirical investigations and assess their results. Moreover, the candidate will develop scientific communication skills by participating at international conferences and writing papers for peer reviewed journals. The researcher may also be involved in teaching activities further developing a strong scientific profile apt for a career both in the research and development field as well as in the university.
Job opportunities	The acquired expertise allows the candidate to apply for positions both in manufacturing companies and in software companies developing advanced manufacturing products. The candidate will gain knowledge to actively operate in the manufacturing digitalisation sector. Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/.

Composition of the research group	0 Full Professors 1 Associated Professors 0 Assistant Professors 4 PhD Students
Name of the research directors	prof. Massimiliano Annoni

Contacts
Email: massimiliano.annoni@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 (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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: INTEGRATED SIMULATION AND SENSOR SOLUTIONS FOR A DIGITAL LASER WELDING PLATFORM IN ELECTRIC MOBILITY

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 electrification of mobility requires a significant change in the manufacturing processes involved in the next generation of vehicles. The battery systems and the electric motor require fewer components with a wider variety of materials, shapes, and thicknesses assembled via fusion welding processes. The rapid evolution of the products requires a rapid adaptation of the manufacturing processes while maintaining a robust production in several locations in a distributed manufacturing scheme. Laser based manufacturing is an inherently adaptable to these products being a versatile and digital tool. Lasers can be adapted to cutting, welding, heat treating, and surface texturing operations by selecting the appropriate beam properties in time, space, and wavelength. Moreover, laser systems lend themselves very well to process monitoring integrating sensors inside the source and or the processing heads. For the end user, the laser technology provides a key solution to the technological requirements, while it also poses challenges in terms of a rapid selection between the different laser technologies. An integrated platform towards a digital twin of the manufacturing process incorporating the manufacturing system, sensor equipment and the product are a requirement for the next generation of sustainable production.This project aims to provide a digital framework to laser-based manufacturing, in particular laser welding, for electric mobility by a complete integration between physical and digital process domains.

	The project involves the use of contemporary high-power lasers with beam shaping capabilities in space and time with novel wavelengths with integrated optical monitoring sensors. The project will integrate the process to multi-physics simulations to provide. The simulation platform will be designed to be flexible to be adapted to the different product needs and will be regulated from high fidelity to mid-fidelity configurations on demand to fit with the needs. High fidelity simulations will be exploited to assess process transients to better understand defect formation mechanisms, while mid-fidelity models will help setting processing conditions at reduced simulation times. The physical process and the virtual simulations will be linked through the sensor systems such as OCT, coaxial cameras, and photodiodes providing data for simulation calibration, validation, and continuous adjustment. The project will demonstrate the applicability of the approach in a fully integrated digital platform across different manufacturing plants. The main application fields will cover the production of the electric drive stator and the contacting of Li-ion battery electrodes. The results will provide the end-users higher flexibility in system design and higher robustness in industrial production enhancing the manufacturing sustainability over higher process efficiency and reduced scrap generation.
Methods and techniques that will be developed and used to carry out the research	1. Implementation of spatial and temporal beam shaping solutions along with wavelength combinations with high power lasers. 2. Experimental study of laser welding on the main electric mobility materials namely Cu, Al, and steel in single and heterogeneous combinations. 3. Process monitoring with OCT and coaxial camera, and photodiode for the development of novel control strategies and data for multi-physics models. Development of a multi-physics simulation solution in loop with the process hardware.
Educational objectives	We provide doctoral candidates with high-level scientific training, fostering and refining research and problem solving abilities by focusing on both theoretical and

	experimental skills. A PhD in Mechanical Engineering will be able to layout, draft and carry on original research, by leading a research group or working in a team.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research: IMA Automation, University of Stuttgart
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 5 PhD Students
Name of the research directors	Prof. Ali Gökhan Demir

Contacts
Research director: 0223998590 aligokhan.demir@polimi.it https://www.mecc.polimi.it/ricerca/sezioni/tecnologie-meccaniche-e-produzione/ 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 (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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activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: TEMPORAL AND SPATIAL CONTROL OF BEAM SHAPING IN LPBF WITH PHYSICS-BASED MODELLING FOR TAILORED PRODUCTS

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	Laser powder bed fusion (LPBF) is arguably the most widely used metal additive manufacturing process in the industry. Today several industries demand higher productivity, better precision, newer materials, and tailored properties to match with the component requirements. Laser beam shaping can provide several options to enhance the processing capabilities by controlling heating and cooling behaviour in a desired manner across larger areas. Contemporary fiber lasers enable flexible control over the power profile in time, while arbitrary beam shapes in space can be achieved in a digital manner by use of dynamic projection devices such as spatial light modulators. On the other hand, the hardware capabilities render only the process development lengthier from the perspective of parameter selection in a much wider space. Hence, efficient modelling tools are required to determine the ideal beam shape in time and space. This PhD project will tackle the needs of next generation metal additive manufacturing with LPBF by integrating beam sources, beam control equipment, and modelling solutions in a single platform. The project foresees the use of a high brilliance laser source with fast temporal switching and ring/core beam shapes coupled to a spatial light modulator launched into a wide area dynamic scanner. The modelling tools foresee the use of multi-physics simulator to generate a database of different solutions. Artificial intelligence methods will be employed

	to shorten the modelling phase by efficient search algorithms as well as developing reduced models to design the most appropriate beam shapes. On-board sensors will be used to calibrate and validate the models. Case studies will concern hard to process materials such as Zn-alloys, FeSi soft magnets, and Cu-alloys.
Methods and techniques that will be developed and used to carry out the research	1. Implementation of spatial and temporal beam shaping solutions with high power lasers and spatial light modulators. 2. Process monitoring with OCT in large area. 3. Process development for demanding materials in electric mobility, biomedical, and electronics applications. 4. Development of a multi-physics simulation solution in loop with the process hardware.
Educational objectives	We provide doctoral candidates with high-level scientific training, fostering and refining research and problem solving abilities by focusing on both theoretical and experimental skills. A PhD in Mechanical Engineering will be able to layout, draft and carry on original research, by leading a research group or working in a team.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research: University of Stuttgart, ENSAM Paris, TU Munich, Optoprim, nLIGHT, Raylase
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 5 PhD Students
Name of the research directors	Prof. Ali Gökhan Demir

Contacts
Research director: 0223998590 aligokhan.demir@polimi.it

https://www.mecc.polimi.it/ricerca/sezioni/tecnologie-meccaniche-e-produzione/
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 (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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POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: HYPERSPECTRAL IMAGING FOR BLACK PLASTICS IDENTIFICATION, SORTING AND RECYCLING

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 increasing use of complex polymeric materials across various industries, such as electronics, packaging and eyewear sectors, has led to significant challenges in managing post-use products. The disposal and recycling of these materials, especially when they come in forms that are hard to differentiate, like black plastics, pose a considerable hurdle for sustainable waste management. This research is driven by the need to address these challenges by exploring advanced methods, such as hyperspectral imaging, to accurately identify and sort different types of polymers. The ultimate goal is to develop efficient processes that allow these materials to be recycled and reintroduced into production cycles, thereby supporting circular economy. By improving the recycling capabilities of complex plastics industry, this research aims to contribute to broader environmental sustainability and reduce the impact of plastic waste.
Methods and techniques that will be developed and used to carry out the research	To carry out the research, several advanced methods and techniques will be developed and employed. Central to this is the use of hyperspectral imaging (HSI) in the mid-wave infrared (MWIR) and short-wave infrared (SWIR) range, a technology that allows for the precise identification of different materials by acquiring their spectral signatures. This technique is particularly effective for polymers that are difficult to classify with conventional methods, such as black plastics. Additionally, advanced algorithms will be developed to enhance the classification

	algorithms will be developed to enhance the classification accuracy and speed, optimizing the process for real-time industrial applications, and exploring the integration of these two camera's ranges. The research will also focus on refining the acquisition of images to balance resolution and processing speed, ensuring the method can be scaled up for continuous, high throughput sorting of polymer waste in industrial recycling processes.
Educational objectives	Acquisition of competences on (i) the development of imaging technologies for automated recycling of complex materials streams, (ii) the development of Artificial Intelligence techniques for hyperspectral data analysis and material identification, (iii) characteristics of black plastics adopted in automotive and electronics, (iv) multi-sensor integration for improved identification and classification.
Job opportunities	Opportunities for jobs in different fields ranging from optical sorting, recycling, manufacturing of polymer-made products and development of digital technologies for circular manufacturing. Potential collaborations with different institutes of the Idea League network, such as TU Delft, with long term experience in circular economy and de-and remanufacturing processes and technologies. Clear link with several SDGs connected with circularity solutions for complex material streams.
Composition of the research group	2 Full Professors 1 Associated Professors 2 Assistant Professors 5 PhD Students
Name of the research directors	Prof. Marcello Colledani

Contacts
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 (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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: MANUFACTURING SYSTEMS ENGINEERING

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	Semiconductor Fabrication is one of the most complex production activities created so far. The number of production steps is in the order of hundreds, there are reentrant flows and time constraints involving different operations, quality requirements are extremely high, many different products with different recipes are produced having different quantities and delivery dates. Therefore, it is an extremely challenging task to design and manage FABs. The objective of the proposed research is to model segments of the production environment to devise appropriate production planning methods and to propose system design methodologies.
Methods and techniques that will be developed and used to carry out the research	One of the main problems when dealing with complex production systems is that their performance is highly dependent on the way the system is managed, i.e. on the characteristics of production planning. Currently available methodologies do not allow to take into account system management at design stage therefore the resulting design may be suboptimal. To overcome this limitation, production planning methodologies have to be integrated with system design methodologies. This will be done by means of response curves obtained by using production planning on various system designs and by optimizing the solution using hyperplanes.
Educational objectives	The student will:

	•Understand the problems related with management of chip fabrication in FABs •Analize real cases and cases available in the literature on chip fabrication and the related FABs •Develop production planning models for segments of chip fabrication process •Develop response curves on the performance of the system under analysis •Develop optimization tools to improve the configuration of the of the FAB under analysis
Job opportunities	•Management and design of FABs for chip fabrication •Production planning and control in fabrication of complex products in various sectors (e.g. automotive, aeronautics, electronics, mechatronics, healthcare) •Design of manufacturing systems for complex products in various sectors (e.g. automotive, aeronautics, electronics, mechatronics, healthcare) List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research include: University of Texas at Austin, KAIST (Korea Advanced Institute of Science &Technology), ST microelectronics
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	Prof. Tullio Tolio

Contacts
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 (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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