Academic Curriculum Vitae

Fabrizio D'Errico (M.Sc. Mech. Eng., Assistant Professor and Adjunct Professor of Metallurgy)

Contact Information

Politecnico di Milano, Department of Mechanical Engineering
Via La Masa 1, 20156 Milan (Italy)
e-mail : fabrizio.derrico@polimi.it
tel. (+39) 02 23998215, fax (+39) 02 2399 8282

Education (qualifications)

2010: University of Oxford, Said Business School - Executive Course "Management of Scientific Research", Oxford (UK)

2008: SDA Bocconi, School of Management - Executive Course "Research and Development Unit Management", Milan (Italy)

2000: M.Sc. in Mech. Eng. at the Politecnico di Milano, Milan (Italy), dissertation thesis title: "Hot Workability of Al 2124-SiCp Metal Matrix Composite"

Professional history at a glance

2005 to present: Assistant Professor and Adjunct Professor of Metallurgy (title pursuant to Italian Law No. 240, 4 November 2005) Department of Mechanical Engineering, Politecnico di Milano (Italy).

2001 to 2004: Lecturer at Università di Brescia (Italy). Course taught: "Metallic and Metal Matrix Composite Materials for Advanced Applications" for a B.Sc. in Mechanical Engineering.

2001 to 2004: Lecturer at Politecnico di Milano (Italy). Course taught: "Experimental and Laboratory Metallurgy" for a BEng in Engineering Materials.

2001 to 2005: Research Assistant at Politecnico di Milano (Italy), Responsible of didactic laboratories for the "*Fundamentals of Metallurgy and Mechanical Technologies"* course for the B.Sc. Eng Degree Program in Mechanical Engineering.

Teaching activity

Courses Taught in Italian

2010 to date: Chair of the *"Metallurgy and Non Metallic Materials"* course for the B.Sc. Degree Program in Mechanical Engineering.

2010 to date: Chair of the *"Applied Metallurgy"* course for the M.Sc. Degree Program in Mechanical Engineering.

2010: Co-Chair of the *"Materials Technology"* course for the B.Sc. Degree Program in Materials Engineering.

2008 to 2010: Chair of the "*Engineering Applications of Metallurgy"* course for the B.Sc. Degree Program in Materials Engineering.

2007 to 2008: Chair of the "*Metallurgy and Non Metallic Materials"* course for the B.Sc. Degree Program in Mechanical Engineering.

2006 to 2008: Chair of the "*Fundamentals of Metallurgy and Mechanical Technologies"* course for the B.Sc. Eng Degree Program in Mechanical Engineering.

2002 to 2003: Chair of the "*Experimental Metallurgy"* course for B.Sc. Degree Program in Materials Engineering.

Courses Taught in English

2013: Invited speaker for the Advanced Seminar on Accident Reconstruction, annual meeting of American National Academy of Forensic Engineering (NAFE) held in Minneapolis, MN (USA). Seminar taught in English for American Professional Engineers working as forensic engineers in American Courts.

2012: Invited speaker for the Advanced Seminar on Accident Reconstruction, annual meeting of American National Academy of Forensic Engineering (NAFE) held in San Diego, CA (USA). Seminar taught in English for American Professional Engineers working as forensic engineers in American Courts.

2010: Chair of the *"Metallic materials and Product Innovation"* course taught in English to an international classroom for the M.Sc. Degree Program in Materials Engineering of Politecnico di Milano.

2010 and 2011: Co-chair for *"Surface Treatments for Mechanical Engineering Applications",* course taught in English to international students at Politecnico di Milano for the M.Sc. in Materials Engineering.

2008: Visiting Professor at Universidad de Oviedo, Spain, for course titled "Thixomolding Magnesium Alloys for Strategic Product Innovation" as a part of course titled: "Seleccion de Materiales en Diseno Mecanico" for the bachelor in Mechanical Engineering, *Escuela Tecnica de Ingegneria Industrial de Gjion*.

Public Grants

Since July 2012: **Project Initiator** and **Scientific Director** appointed by Project Coordinator of the collaborative EU project *InGRID,* a 32MLN Euro and 7 partners project co-financed on Energy-2 EU Call (ref: Grant Agreement n.296012). The project aims to combine recent advances in Smart Grids and solid-state hydrogen gas storage realized by mean of magnesium metal to match energy supply and demand and optimize the electricity generated by intermittent renewable energy sources while ensuring security and stability of the power distribution network.

Jan 2012 to May 2013: **Project Initiator** and **Project Coordinator** of the EU project *"Integrated Renewable-Hydrogen-Magnesium Pilot Plant for Green-energy High-capacity production" or "RHM"* (code: LIFE+2010 ENV IT 323). Project started in January 2012 aimed to construct a small-scale pilot plant to demonstrate technical and economic feasibility of double-extraction of hydrogen and magnesium from seawater by use of desalination and preferential salt separation (DPSS) technology, coupled with two electrolyzing routes for producing hydrogen and magnesium respectively from distilled water and MgCl2.
NOTE: The 48 month project fault and was terminated after 15 months because the subcontractor, who was sole supplier of the DPSS technology, withdrew from the market.

Sept 2009 to August 2013: **Project Initiator** and **Project Coordinator** of *"Green Metallurgy project: Industrial pilot project for lean integrated process cycle for eco-sustainable production of high performing magnesium components"* (ref: LIFE09 ENV/IT/000117) an EU LIFE project co-founded on LIFE 2009 EU Calls. The 36 months project started on 1 September 2009 and concluded on 31 August 2013. Scope of the project was the development of a pre-industrial pilot plant to produce extruded semi-finished bars made of ternary Mg-Y-Zn nanostructured alloys and ultrafine Eco-Magnesium® alloys using the same no-melt process routes.

Invited talks

2014: 143th Annual American Minerals, Metals & Materials Society (TMS) meeting, San Diego, CA (USA) – Magnesium Symposium Technology, Invited key-note speaker (ref. to list of all publications).

2011: 140th Annual American Minerals, Metals & Materials Society (TMS) meeting, San Diego, CA (USA) – Magnesium Symposium Technology, Invited key-note speaker (ref. to list of all publications).

Awards

2013: Light Metal Division "Magnesium Technology" Best Paper Award, category "Application", 2012 TMS Annual Meeting & Exhibition. *The Minerals, Metals and Materials Society (TMS) honors the best among the materials science and engineering community with awards presented yearly during the TMS Annual Meeting & Exhibition* (ref. to list of all publications).

Patents:

2006: Italian Patent n°0001375863: Magnesium Thixomolded Monolithic Node for Joining Bicycle Frame Elements, 2006 (ref. to list of all publications).

Committees and councils

2012 to date: Member of the Editorial Board of *"Case Studies in Engineering Failure Analysis"* international journal published by Elsevier.

2011 to date: Member of the Technical Magnesium Committee, part of the Light Metals Division at the American TMS, The Minerals, Metals & Materials Society.

2014: 143th Annual TMS meeting, San Diego, CA (USA) – Magnesium Symposium Technology, Session Chair

2012: 141th Annual TMS meeting, Orlando, FL (USA) – Magnesium Symposium Technology, Session Chair

2012: The *V International Conference of Engineering Failure Analysis*, The Hague (The Netherlands), Session Chair.

2010: The VI International Conference of Engineering Failure Analysis, Cambridge (UK), Session Chair.

2004 to 2010: Member of the technical committee for "Transport Means and Design for Environment" part of the Italian Association of Design (ADI). The Board participates in the selection of candidates for the European Prize, *Compasso D'Oro*.

Research areas and themes

The candidate's **research activity** is divided into **5 research themes** which are summarized below.

1.Advanced metal matrix composite materials. During his dissertation thesis, the candidate sited research in the metal matrix composite field (MMC). A numerical model has been developed to fit results of experimental tests (i.e. compression conducted at varying deformation rates and temperatures) and ultimate construction of hot deformation maps. Safe conditions of hot-deformability of aluminum-based composite materials have been researched and material microstructure profoundly investigated in relation to mechanical behavior. An innovative fabrication process by infiltration of aluminum has been researched for the production of MMC with very high ceramic reinforcement content.

2.Surface treatments and coatings of mechanical parts subjected to dynamic loading. Research activity regarding the influences of microstructure on the mechanical behavior of surface layers that are dynamically loaded (e.g. contact fatigue and high-cycle fatigue loading). To this scope, mechanical behavior under cyclic loading of hard layers produced by conventional thermo-chemical treatments (i.e. case-hardening, carburizing and nitriding) and surface coatings has been investigated. Metallurgical and mechanical characterization of these surface layers have been followed by the study of the mechanisms involved in the initiation and subsequent propagation of surface micro-cracks. Specifically, different responses to micro-pitting, pitting and spalling of surface layers produced by nitriding and carburizing have been investigated. Furthermore, effects of compressive residual states of stress induced by thin coating layers deposition on the fatigue limits of steel have been investigated.

3.Advanced manufacturing processes for high-performance magnesium alloys. This research early focused on the study of mechanical properties of magnesium alloys fabricated by semisolid-route processes, particularly the Thixomolding® process. . To produce magnesium near- net- shape complex parts with higher mechanical properties for dynamic loading then conventional die-casting processes has been a goal of the automotive sector since before the 2008 crisis. To enhance mechanical properties of thixo-magnesium alloys, a special heat treatment was developed that is capable of reducing the total amount of the brittle network of aluminum-enriched β-phase that forms around grains during the semisolid injection and following the cooling down phase. The need to increase the use of magnesium alloys in lightweight vehicles, resulted in research processes that allow extra refinement of microstructures. Ternary Mg-Y-Zn alloys produced from rapid solidified powders to the solid-state have been extensively investigated during the LIFE09 ENV IT 117 “Green Metallurgy” EU project, because of the highly mechanical properties realized by their nanostructure. The same process route has been developed for commercial recycled chips of Eco-Magnesium alloys. A Life Cycle Analysis has been performed to assess global warming potential of this process route. The “Green Metallurgy” process route for Eco-Magnesium recycled chips has shown the lowest carbon footprint over other conventional manufacturing processes. Furthermore, early studies performed at the *Centro Nacional of Investigaciones Metalurgica* (CENIM) in Madrid focused on developing a viable method for reducing grain size of Eco-magnesium chips by utilizing the cryo-milling process. Such a process route is key for the production of the nanostructure of quasi-pure magnesium, namely the main component of a composite material, made of magnesium and graphite developed at the *Commissariat à L'énergie Atomique et aux Energies Alternatives* (CEA) in Grenoble as a means of hydrogen solid-state storage. Industrial applications of these materials have been addressed in the EU Large Collaborative project “INGRID”.

4.Engineering Failure Analysis Methods applied to product re-design and Forensic Engineering. Failures during operations are commonly evaluated through engineering failure analysis methods, of which metal failure analysis is a branch. The goal is to identify mechanisms of failure and seek out mitigating solutions to prevent similar failures from occurring again. Methodological studies applied to several cases of failures went beyond the analysis of experimental observation to verify hypothesis, and the entire reconstruction of events that provoked the failure was researched. Reconstructing a failure event goes beyond the identification of pure metal failure mechanisms; root causes of failures and the relative contribution of hexogen (e.g. load, surface condition, environment, etc.) and endogen (e.g. microstructure and its relationship with product mechanical response) factors are investigated in order to provide guidelines in re-design and in the optimization of industrial products. Root cause failure analysis (RCFA) has been coupled with most common engineering methods for safe-design and risk-management such as FMEA (Failure Mode and Effect Analysis) and causal diagrams (most widely known, the Ishikawa Diagram). Through this analysis specific expertise has been acquired in the forensic field, specifically in the reconstruction of complex accidents, primarily in the transportation sector. The need of scientific methods to precisely reconstruct failure events in the forensic field - primarily those related to criminal cases that involve complex organizations – led to a research theory of accidents, as well as the sequence of events that happen before and during an accident in relationship to the models of accident causation (J.T.Reason, 1997). The final outcome has been a general methodology that uses causality principles, the general relationship among

police evidence and universal laws, employing a framework which allows non-technical personnel to understand if all the events have been accurately reconstructed on the basis of the evidence.

5.Engineering Material Selection Strategy for Product Innovation. Material Selection Methodologies (MSM) in engineering design is about making decisions, often with uncertain and conflicting criteria. MSMs are constructed to seek out optimum material choices throughout a combination of certain factors. These factors may include independent variables with controlled or design parameters, which allow us to obtain a product characterized by a defined number of desired properties. Those properties may include dependent variables, response characteristic qualities and functional requirements, which allow us to make decisions in Multi Objective Optimization (MOO) problems. A decision making problem is defined as multi-objective if its solution consists in identifying multiple objectives that somehow have to be combined in order to yield one final solution. It is not likely that there exists a solution which simultaneously minimizes all the objectives. The multi-objective optimization methods can be divided into non-derivative, or implicit methods, and derivative, or explicit, methods, as taught in "*Metallic Materials and Product Innovation"* and *"Applied Metallurgy"* courses *(refer to "Teaching Activity"* section in this curriculum vitae*)*. A derivative method, or explicit method for material selection, describes explicitly a material "optimization function" - e.g. the weight-saving function of a component that is bend loaded - in terms of dependent material variables – e.g. density, elastic module, etc. A non-derivative method, or implicit method, on the other hand, does not derive the objective functions in order to calculate the optimum. They are also known as "black box methods". Each explicit or implicit method contains some advantages and some disadvantages, especially in the case of the industrial product development process that is key for competing in the marketplace. Research conducted since 2010 in classroom activities has brought the development of a methodology for assessing innovative content of a new product. Experimental classroom workouts performed during the "Metallurgy Applied" course (refer to teaching activity section in this curriculum vitae) for the academic years 2012/2013 and 2013/14 brought about the start out and development of a hybrid method for a material selection strategy that combines in an implicit tool - the most widely known is the QFD method (Akao, 1990; Juran, 1988) with its higher flexibility and rapidity - the powerful, precise but low flexible approach of an explicit tool based on Performance Material Indexes (Ashby, 2004).

Primary Industry Research Activities

- Customer: Saipem, Eni Group (2005-2006) "Simulating Trench Test Materials for Pipeline". Role: Project Manager. Project budget: 375 k€;
- Rollon S.p.A. (2006-2007) "Optimization and Selection of Alternative Material and Surface Hardening Processes for Linear Guides", Role: responsible for research activity. Research activity budget: 20k€;
- Brembo S.p.A. (2005-2009) "Transfer of Know-how on Root Case Failure Analysis Methods for Scientific Support to the Advanced R&D Units", Co-responsible for research activity. Research activity budget: 80k€;
- Nadella S.p.A. (2012-2013) "Transfer of Know-how on Experimental Procedure for the Selection of Material and Surface Hardening Processes for Linear Guides", Responsible for research activity: F.D'Errico (15k€)

Milan, October 2014