DESIGN OF MECHANICAL COMPONENTS USING ADDITIVE MANUFACTURING

AIAS Summer School
For PhD students and young researchers
Ferrara, June 12-15, 2017 – AIAS (The Italian Scientific Society of Mechanical Design)

	Monday	*Tuesday*	*Wednesday*	*Thursday*
	June 12, 2017	June 13, 2017	June 14, 2017	June 15, 2017
		9:30-13:00	10:30-12:30	9:00-12:00
morning		***Prof A.A. Zadpoor*** Delft University of Technology	***Prof P. Bariani*** University of Padua	**Prof. P. Citti** Guglielmo Marconi University **Ing. E. Gonfiotti** GE Oil & Gas *Additive manufacturing in Turbomachinery*
		Mechanical meta-metarials	*Materials and Technologies for additive manufacturing*	12:15-13:30 **Prof. F. Auricchio** University of Pavia *Micro and macro modelling of additive manufacturing processes*
	14:00 *Registration, Opening of course*	13:00 – 14:00 *lunch*	13:00 – 14:15 *lunch*	13:30 – 14:15 *lunch*
afternoon				
	14:30-18:30	14:30-18:00	14:30-16:30	14:15-16:00
	Prof G. Nicoletto University of Parma	***Prof M. Guagliano*** ***Dott. Ing. S. Bagheirfard*** Politecnico di Milano	***Prof P. Bariani*** University of Padua	***Prof. L. Vergani*** Politecnico di Milano
	Design and development of advanced metal parts using additive manufacturing	*Cold spray: from coating to additive manufacturing. Process, equipment and characterization*	*Visit and demos at Laboratory for Precision and Micro Manufacturing*	*Final test and Ph.D.* activity *presentation*

Conference Venue, IUSS – Ferrara 1391 - via delle Scienze, 41/B

Local Organising Committee

Prof. P. Livieri – *Universita di Ferrara*
Prof. G. Nicoletto – *Università di Parma*
Prof. R. Tovo – *Universita di Ferrara*
Prof. L. Vergani – *Politecnico di Milano*

Monday 12/06

DESIGN AND DEVELOPMENT OF ADVANCED METAL PARTS USING ADDITIVE MANUFACTURING

Speaker: prof. Gianni Nicoletto (University of Parma**)**

Total 4 hrs including breaks

Additive Manufacturing (AM) offers the possibility to produce complex parts without the design constraints of traditional manufacturing routes. No longer solely a prototyping technology, AM is now being used for the production of series components for the most demanding applications. Powder bed fusion is a key segment of metal additive manufacturing. The success of PBF technology however resides in understanding, acceptance and exploitation of its peculiar features by designers and engineers.

Part 1 - Additive manufacturing of metals: powder-bed-fusion technology, materials, fields of application, growth potential
This presentation reviews the powder bed fusion technology, the range of metals that can be processed, the design drivers specific of AM and several successful applications in different industrial fields. The potential for growth of the technology and the needs are discussed.

Part 2 – Impact of the metal additive manufacturing technology on structural design
The PBF technology produces functional parts starting from metallic powder that is selectively melted and rapidly solidified layer-by-layer with minimum material waste. Differently from conventional manufacturing routes, additive manufacturing allows the designer to conceive parts of unimaginable complexity, which are nonetheless readily produced. The powerful design drivers of metal additive technology and the associated CAE tools are presented and discussed in the structural design context.

Part 3 - Fatigue and fracture characterization of PBF metals
Fatigue design in industry relies on a vast body of knowledge in terms of design methods and norms and material allowables in relation to established manufacturing technologies. The assessment of part performance by engineers requires mechanical properties for the AM processed materials. Specific test methods for AM metals and recent fatigue and fracture test results for PBF Ti6Al4V and PBF Inconel 718 are presented and discussed.

Tuesday 13/06

ADDITIVELY MANUFACTURED META-(BIO)MATERIALS

<u>Morning</u>

Speaker: prof. Prof. Amir A. Zadpoor (Delft University of Technology**)**

Total 3.5 hrs including breaks

The lecture will cover different aspects of metamaterials particularly for applications in biomechanics and biomedical engineering including tissue regeneration and infection prevention.
Since most relevant designs of metamaterials require complex geometries that could only be realized using additive manufacturing, there is an intimate connection between the design of metamaterials and additive manufacturing technologies. The relevant additive manufacturing technologies and their potential for fabrication of metamaterials will be therefore discussed.
The mechanical, physical, and biological properties of additively manufactured metamaterials will be also covered so as to highlight the latest results and trends.

COLD SPRAY: FROM COATING TO ADDITIVE MANUFACTURING. PROCESS, EQUIPMENT AND CHARACTERIZATION

Afternoon

Speaker: prof. Mario Guagliano and *Dott. Ing. S. Bagheirfard* (Politecnico di Milano**)**

Total 3.5 hrs including breaks

Cold Gas Dynamic Spray, or simply Cold Spray, is a recent technology originally developed in the former Soviet Union and is gaining an increasing interest in different industrial fields.
Basically it consists in shooting appropriate powders against a target material with a velocity high enough to cause the adhesion of the particles to the substrate. While it was initially utilized as coating process, it is now getting attention as a potential process to fabricate 3D free standing parts. However, the potentiality of cold spray as additive manufacturing technique is still to be explored both in terms of the properties that can be achieved and in terms of economic convenience with respect of more developed AM technologies.

The first part of the talk introduces the physics of cold spray and highlights the critical issues related to the correct application of the process. Then the different cold spray facilities are described as well as their pros and cons. An overview of the present popular applications of cold spray concludes the first part of the presentation.

In the second part of the presentation the methods for the characterization of the cold sprayed parts are presented and critically reviewed. Then the attention is focused on the applications of cold spray and on the most recent results in the field. In particular, the application of cold spray for structural repairs and for building 3D free standing parts is critically discussed on the base of the results available in literature and obtained by the research group.

Wednesday 14/06

VISIT AND DEMOS AT LABORATORY FOR PRECISION AND MICRO MANUFACTURING

Prof Paolo Bariani (Unversity of Padua**)**
Laboratorio TeSi - ROVIGO Viale Porta Adige, 45, 45100

Thursday 15/06

ADDITIVE MANUFACTURING IN TURBOMACHINERY

Morning

Speaker: prof. P. Citti (Guglielmo Marconi University**) and Ing. E. Gonfiotti (**GE Oil & Gas)

Total 3 hrs including breaks

MACRO- AND MICROSCOPIC SIMULATION OF ADDITIVE MANUFACTURING PROCESSES

Speaker: prof. F. Auricchio (University of Pavia**)**

Total 1.15 hrs

Additive Manufacturing (AM) is taking off in many industrial processes. In particular, powder bed fusion for metal manufacturing has definitively changed the way of prototyping metal parts: in fact it allows geometries and resolution precision that were unthinkable just not too long ago. However, AM is a very complex process that involves different phenomena, e.g., heat conduction, phase change, surface change and residual stress rising; accordingly, it is a complex coupled thermo-mechanical problem and simulation is fundamental to predict temperature distribution and stresses during and after the printing process.

The first part of the presentation focuses on microscopic simulations, involving three physical problems: powder melting/solidification, melt pool fluid motion, geometry surface change. The problem has been approached with Lattice Boltzmann Method, able to manage different fluid and different phases, making it ideal to describe the time evolution of the powder bed after melting. Preliminary results of fluid and thermo-dynamic problems are presented.

The second part of the presentation focuses on a macroscopic simulation performed using the commercial code ABAQUS (Dassault Systèmes). Once defined number of layers and the laser path, the thermo-mechanical analysis is divided in two steps. First the heat transfer analysis is carried out modeling both the powder bed properties (absorption, diffusion, etc.) and heat source specifics (spot diameter, power, penetration depth, etc.). Then the mechanical analysis is performed including the temperature distribution obtained from the mechanical one. It is then possible to evaluate temperature distribution and residual stresses on the printed part.

FINAL TEST AND PH.D. ACTIVITY PRESENTATION
Afternoon

Speaker: prof.ssa Laura Vergani (Politecnico di Milano)
Total 2 hrs