Title:

Additive Manufacturing by selective laser melting (SLM) of Iron and Ti-based alloys. Process - microstructure- mechanical and magnetic properties.

Topics:

IV-6. Calculation of materials and simulation for design
IV-8. New metallic materials (super strength, long lifespan)
IV-13. Equipment for advanced materials and technology of forming process

Keys words:

Additive Manufacturing, materials, design, optimization, modeling

Skills and background of the applicant:

Additive Manufacturing, physics of materials, concepts in design, technical materials characterization, bases in the simulation and modeling.

Summary:

Additive Manufacturing (AM) is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies, such as traditional machining.

On a metallurgical level, the SLM involves fast fusion-solidification kinetics on reduced melting zones (<1 mm), which lead to the formation of very specific microstructures. When the process is not well optimized, defects such as porosities or cracks appear. The conditions of formation of the microstructures and defects and their impact on the mechanical and magnetic properties of the parts produced are still insufficiently known. Also, The non-uniform expansion and contraction of the material during the thermal cycle results in residual stresses and distortion. To obtain a better understanding of the thermo-mechanical performance of the AM process, a study based on simulation will be developed in this thesis.

The aim of this work is to show that the residual stresses and the distortions are possible to be reduced using optimized deposition parameters and sequences.
Focusing on Iron and Ti-based alloys for applications in energy and magnetism, the thesis subject will be based on three main axes:

- Make a bibliographic research on the interactions between Additive Manufacturing - Microstructures - mechanical and magnetic properties in the case of Fe and Ti based alloys.

- Perform an experimental methodology, defining optimal parameters for the SLM process by characterizing the morphological and metallurgical states of the fabricated material. The homogeneity and possible anisotropy of the microstructural state and of properties will be more particularly suitable. In addition to the use of additive manufacturing machines (SLM machines), various technical analysis of the microstructure (SEM, DRX, profilometry ...), mechanical and magnetic properties (microhardness, residual stresses, coercitivity, hysteresis cycles ) will be used.

- The mechanism of the stress generation during the deposition process will be analysed via a 3D thermo-mechanical model.

- An optimization of the post-fabrication thermal treatments will allow, through the control of the microstructures, to obtain materials with the desired properties.

**Project partners and collaborations:**

This work will be developed as a transversal collaboration between PMDM and COMM research groups inside ICB Laboratory.

**Our background and scientific competences in Additive Manufacturing:**

1- Zhang, Baicheng; **Fenneche, Nour-Eddine**; Liao, Hanlin; et al. Microstructure and Magnetic Properties of Fe-Ni Alloy Fabricated by Selective Laser Melting Fe/Ni Mixed Powders JOURNAL OF MATERIALS SCIENCE & TECHNOLOGY Vol. 29 Issue: 8 Pages: 757-760 DOI: 10.1016/j.jmst.2013.05.001 Published: AUG 2013


3- Zhang Baicheng; **Fenneche, N.**; Zhu Lin; et al. Studies of magnetic properties of permalloy (Fe-30%Ni) prepared by SLM technology JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS Volume: 324 Issue: 4 Pages: 495-500, Published: FEB 2012