Doctoral position in the field of Cold Spray Additive Manufacturing.

PhD thesis entitled:

3D Near net shape fabrication of bulk metallic components via the optimization of cold spray additive manufacturing.

Specification of the PhD diploma:

Engineering science

Key-words:

Cold spraying, 3D parts, metals, near-net-shaping, properties, machine learning, computational analysis, predictive simulation.

Details of the subject:

Topic description:

To date, substantial efforts have been made for the development of additive manufacturing processes among which the solid-state additive elaboration emerges as an innovative method, and particularly the CGDS process (Cold Gs Dynamic Spraying). The primary realizations of this process were the fabrication of thin metallic coatings but nowadays various technological solutions have been developed for different applications in engineering, health and societal live [1]. Several CGDS deposits were performed for surface functionalization, structural or dimensional restoration, bulk production or art and decoration, providing specific material properties or innovations. The cold spray process has become a high value-added manufacturing method which covers a broad range of materials including advanced ones [2]. Cold spraying is also believed to bring further potentials in the future. In the field of rapid prototyping of 3D complex shape, the CGDS method brings encouraging results and one of major challenges is the minimization of sprayed material surplus and also the fine control of nozzle trajectory [3]. Research works on these aspects are crucial to make the CGDS a viable method for a direct and fast fabrication of industrial parts using powder technology. The objective of this doctoral study is to explore all the possibilities to achieve such results, while also optimizing both deposition efficiency and structural properties of the CGDS 3D parts.

Research works:

The success of cold spraying as reliable AM method to fabricate complex shape depends on better expertise regarding the control of the deposit track. For this purpose, we suggest to perform research works through two major milestones: an identification of strategies for manufacturing 3D parts and then, an optimization of the working conditions. A specific work package will then focus on the 3D prototyping of generic geometric shapes based on suitable deposition strategies to be identified through numerical simulation coupled with experimental testing. This part will develop viable additive trajectories and will benefit from knowledges we already developed within the LERMPS team of the laboratory Institut Carnot de Bourgogne [4,5]. We also expect to depict the difficulties of manufacturing due to geometric limitations, structural distortions and other problems that can be generated by the 3D prototyping of metallic parts using the additive Cold Spraying method. The other substantial part of this doctoral study is a restitution work that draws up guidance and recommendations for 3D CGDS manufacturing capable for a high-fidelity near net shaping of several variances of 3D parts. This restitution work will also include the identification of conditions that optimize the deposition efficiency by developing machine learning algorithms capable for predicting suitable selection of process parameters depending on the features of the 3D part (shape and properties).

Research environment:

The PhD candidate will perform the research works at the laboratory Institut Carnot de Bourgogne, within the research team LERMPS which is the former LERMPS (Laboratoire d'Etudes et de Recherches sur les Matériaux, les Procédés et les Surfaces) created in 1986. In 2017, the LERMPS joinded the Institut Carnot de Bourgogne (ICB) which is a Research Unit of the CNRS (UMR 6303). The LERMPS team is attached to the Metallurgical Processes, Material Durability (PMDM) department of the ICB. The doctoral studies will benefit from the research facilities on the platform TiTan of the LERMPS (technological site of Sevenans - Université de Technologie de Belfort Montbéliard). He/She will have access to various experimental and numerical resources (Cold Spraying installation, rapid imaging diagnostic device, multi-physics simulation software ANSYS, COMSOL, Abaqus, access to a cluster for CFD/discrete phase numerical simulation, structural observation and characterization means). The research works will also take advantage of recent results we obtained during two PhD works that are focused on machine learning applied to thermal spraying, and on the optimization of additive layer growth for the construction of 3D shapes by Cold Spraying (Figure 1). The candidate will refine both numerical models and manufacturing strategies for CGDS 3D parts in order to provide operational tools, method and guidance through virtual tests (predictive multi-physics simulation) and through machine learning. This research work is not subjected to a confidentiality clause and allows thereby scientific dissemination (conference, publication, thematic day) of the whole results we will obtain. In achieving this outcome, the PhD student has the capabilities to perform experimental testing across material and mechanical disciplines, and to investigate phenomenological analysis through both experimental characterization and computer simulation/numerical modelling (CFD, machine learning).

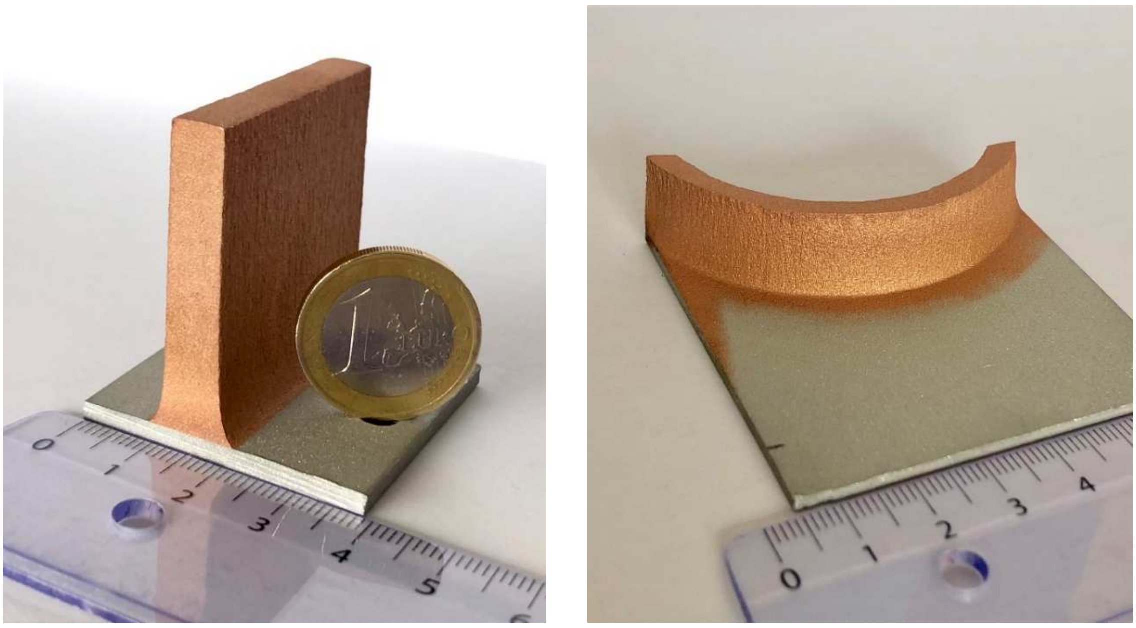

Figure 1: 3D parts produced by Cold Spraying (results of thesis works performed by Hongjian Wu)

Additional information:

The PhD study is scheduled to begin in September 2020. Net monthly remuneration: ~1400€

Deadline for the application: June 10th, 2020. Please send a CV, a cover letter, scores of both current and last academic years, and copies of Master diplomas or similar.

Expected background of the PhD candidate:

Capabilities for managing and performing extensive experimental testing, numerical programming, optimization, numerical simulation methods, mechanics and materials.

References:

[1] R.N. Raoelison, C. Verdy, H. Liao, Cold gas dynamic spray additive manufacturing today: Deposit possibilities, technological solutions and viable applications, Mater. Des. 133 (2017) 266–287. doi:10.1016/j.matdes.2017.07.067.

[2] R.N. Raoelison, Coeval Cold Spray Additive Manufacturing Variances and Innovative Contributions, in: Cold-Spray Coat., Springer, Cham, 2018: pp. 57–94. doi:10.1007/978-3-319-67183-3_3.

[3] M.E. Lynch, W. Gu, T. El-Wardany, A. Hsu, D. Viens, A. Nardi, M. Klecka, Design and topology/shape structural optimisation for additively manufactured cold sprayed components, Virtual Phys. Prototyp. 8 (2013) 213–231. doi:10.1080/17452759.2013.837629.

[4] A novel spiral trajectory for damage component recovery with cold spray - ScienceDirect, (n.d.). https://www.sciencedirect.com/science/article/pii/S0257897216310933 (accessed April 21, 2018).

[5] S. Deng, Z. Cai, D. Fang, H. Liao, G. Montavon, Application of robot offline programming in thermal spraying, Surf. Coat. Technol. 206 (2012) 3875–3882. doi:10.1016/j.surfcoat.2012.03.038.

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