RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Materials Science, Mechanics, Fluids

Subfield: Materials Science and Manufacturing

Title: 4D printing of net-shape part made of Ni-Ti shape memory alloys fabricated by laser additive manufacturing

ParisTech School: Arts et Métiers

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Short description of possible research topics for a PhD:

Nitinol is one of the most utilized alloys exhibiting the Shape Memory Effect, which makes it possible to use it in many applications, such as aerospace, automotive, biomedical and others. However, processing nitinol is highly sensitive to compositional and thermal changes, affecting the final phase structure and properties. Consequently, it shows very low machinability, which significantly impedes the manufacturing of complex components.
Recently, laser additive manufacturing (LAM) technologies, including powder feeding or powder bed, have been considered as one possible near net-shaped process to overcome these shortages. In particular, 4D printing allows creating the latest time-dependent 4D products from nitinol that can realize the Shape Memory Effect after 3D-printing. But laser, as one type of high energy beams, brings the inevitable vaporization or chemical micro-segregation, which greatly affects the thermal and mechanical behaviors of Nitinol.
In this project, the multi-scaled characterization methods, such as, 3D tomography, optic and electron microscopies will be employed for analysis of the densification behavior, microstructure, thermal and mechanical properties of laser additive manufactured Ni-Ti shape memory alloys. Then, according to the obtained process parameters-structure-properties relationship, a closed-cycling control processing will be established for the 4D printing technology. Since the connection between manufacturing process control parameters and actual functional capability is of paramount importance, the understanding of the operational variables needs to be improved. Full-field methods (Phase-field and Level-set) will be developed to address the issue concerning the effect of process parameters on the final performance of a manufactured SMAs part.

Required background of the student:

The PhD candidate must have a solid knowledge of metal manufacturing process, in particular laser additive manufacturing, Materials Science, Metallurgy and Characterization methods (SEM, MET, XRD). Besides, numerical skills (Python) and good understanding of finite element methods are required.

A list of 5 (max.) representative publications of the group:

[1] N. Kang, X. Lin, M. El Mansori, Q.Z. Wang, J.L. Lu, C. Coddet, W.D. Huang, Additive Manufacturing 31 (2020) 100911.
[2] Kang, N., El Mansori, M. (2020) Tribology International, 149.
[3] Kang, N., Lu, J.L., Li, Q.G., Cao, Y.N., Lin, X., Wang, L.L., Huang, W.D., El Mansori, M. (2020) Vacuum, 179, art. no. 109557.
[4] Kang, N., Lin, X., Mansori, M.E., Wang, Q.Z., Lu, J.L., Coddet, C., Huang, W.D., (2020) Additive Manufacturing, 31, art. no. 100911.
[5] Kang, N., El Mansori, M., Lu, J.L., Lin, X., Huang, W.D. (2019) Wear, 426-427, pp. 934-941.