PhD Grants from the China Scholarship Council: Co-operation Program with the UTs and INSAs (France), Program 2020

Thesis subject:

Development, characterization and modelling of bulk Al alloys materials with improved mechanical properties conferred by high strain rate self-consolidation.

Keywords:

Al alloys, high strain rate, structure, properties, modelling, constitutive law

Description:

Technological context and current issues:

High speed impact welding is a new innovative joining process capable of combining various metals. The high strain rate collision generated by the impact process between the two parts to weld involves complex kinematics and non-equilibrium transformations that create a welded joint while conferring also a gradient of structure and increased mechanical properties across the welded interface, whose formation and occurrence were depicted through computational analysis of the dynamic collision process at the interface combined with various structural characterization [1,2]. A confinement of high strain rate at the interface during the high-speed collision has been identified as major phenomenon that governs those interfacial structural changes and mechanical properties improvement [3]. A few cases of aluminum alloys were investigated and resulted in this property gradient finding with the metallurgical transformations the thermally affected zones produce. One of our current objectives is to take advantage of these results to develop bulk aluminum material with improved properties based on these high strain rate phenomena. Today, such aluminum material is of high interest since they can contribute for a further lightweighting for several application such as for aircraft design, vehicle reinforcement or similar performances. The bulk materials will be manufactured by a solid-state additive method that also uses a high strain rate collision with impact velocity range similar to that of high-speed impact welding. By a continuous ballistic collision of micron powders, the cold spray process enables for creating, layer by layer, a self-consolidated bulk component [4].

Research works:

This PhD work focuses on the development, characterization and modelling of bulk Al alloys materials with improved mechanical properties conferred by high strain rate self-consolidation. The candidate will develop knowledges about the metallurgical transformations generated by the process, and their intrinsic features including the properties they create. For that purpose, various structural analysis will be performed to characterize the material using fine analysis (SEM, EBDS, TEM, nano-identation). The intrinsic properties of the high strain rate induced structure will be correlated to macroscopic mechanical behaviors of the material characterized by mechanical testing. Thus, predictive elastic-plastic bulk behavior coupled with damage evolution will be

developed from micro-structural features of the material, using a micromechanical modelling approach [5,6]. Then, the predictive model will be used to depict the suitable structures for optimum properties, and thereby to develop optimized bulk component based on the suitable selection of cold spray conditions including the powder features and the process setting. The numerical modelling will be performed using Matlab and Abaqus 6.14 packages.

Expected background of the PhD candidate:

Computational material science, Mechanics of materials, Finite element method, Structural characterization, Metallurgy of aluminum alloy

Supervision of the research works and collaboration:

Supervisor: M. Rachik [1]
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Collaboration: T. Sapanathan [3]

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