NUMERICAL MODELLING OF TECHNOLOGIES AND DESIGN OF INNOVATIVE COMPOSITE MATERIALS

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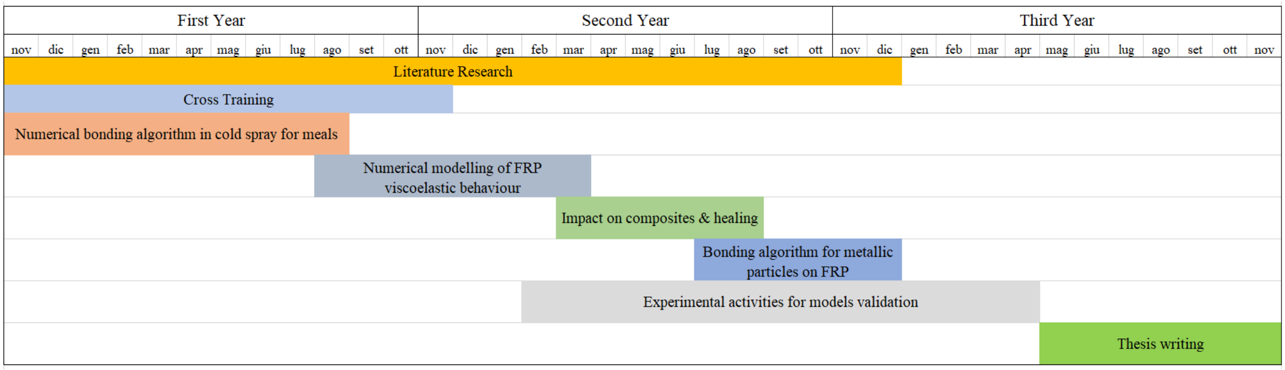
The industrial fields are constantly adapting to offer more reliable and safer products in an ever-changing market. Sectors like aerospace, railways and automotive are constantly looking for new solutions for weight reduction and fuel cost saving to obtain a competitive advantage over their competitors. From the scientific point of view this represents an opportunity to develop and investigate new solutions for innovative composite materials design, damage prediction as well as healing and repairing technologies. An intriguing application of new materials is represented by the metallization of a fiber reinforced polymers (FRP) through the deposition of a metallic microparticle coating. This kind of solution allows to confer a diametrically opposite material surface properties with the slightest weight gain. Although many experimental studies were conducted about FRP metallization, the adhesion mechanism of metallic particles to the composite substrate results unexplored and object of study. As widely demonstrated [1–5] the opportunity to apply a metallic surface coating to an FRP is enabling by using Cold Spray (CS) technology. Experimental tests to verify the coating quality and strength both on thermosetting [2,3] and thermoplastic [3,6,7,8] were conducted as well as numerical approach to define a proper range of technological parameters was adopted [5,9]. However, the adoption of a numerical approach to conduct detailed investigation on the metal particles to composite substrate dynamic and thermo-mechanical interaction, is an unexplored field of research. In this regard phenomena of local temperature increasing due to particle to substrate mechanical interaction during the impact, as well as its effect on viscoelastic polymers response, particularly for deposition of coating on thermoplastic polymers, cannot be appreciated and verified through experimental campaigns. The main aim of this thesis work is the development of a numerical approach to the definition of thermo-mechanical condition allowing the adhesion of metallic powders cold sprayed on a FRP with particular focus about fiber composite reinforced by using thermoplastic polymers. The formulation and validation of such an algorithm will allow the analysis of process parameters on the substrate strength properties and the optimization of technological parameters themselves.



The proposed thesis project GANTT chart reposts both the carried out and the to do activities for the three years of PhD. The project started with the deepening and publishing of the master’s degree thesis activity about the formulation of a bonding algorithm for cold sprayed metallic particles on metallic substrates. At the same time, with the purpose to build the necessary know-how about dynamic and static numerical model, an analytical solution for the interference fit joints was developed thanks to the adoption of a numerical implicit analysis methodology a numerical activity on the curling process for metallic capsules resulted fundamental to acquire the necessary skills in nonlinear material implementing in numerical routine. The acquired competences, the numerical tool was used to model the viscoelastic behavior of thermoplastic polymers when subjected to thermo-mechanical loads. Viscoelasticity of material response was applied to FRP model to appreciate the influence of viscous shear on the response of composite materials under dynamic loads and on it damaging. Currently the numerical research activity is focused on the FRP damage mechanism investigation with particular attention to the response of hybrid composite laminates in different stacking configurations under dynamic and quasi-static testing condition. The developing numerical model is allowing to investigate the different damage mechanisms occurring, their distribution in the material thickness and their extension on the principal in-plane directions. In dependence of the stacking sequence and energy level, the energy absorption capacity will be estimated and related to the dominant damage mechanism. Percentage contribution of interlaminar and intralaminar damage on the total damage occurring will be presented by specifying the areas interested by delamination for each ply-to-ply interface and the contribution of each ply to the total intralaminar damage. On this background will be possible to implement an algorithm for the adhesion of metallic powder cold sprayed on thermoplastic fiber reinforced polymers taking into account all the sprayed material to composite substrate interaction and damaging.

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Matteo Bruno, PhD student XXXV cycle, May 2021