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- *Composite materials: surface protection coatings by means of cold spray technology*
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OUTLINE OF THE RESEARCH

Since the 1990s, composite materials have been the subject of renewed interest and considerable development, deriving from the needs of some industrial sectors to have materials with high mechanical properties and chemical stability, accompanied by high rigidity / weight ratios. The relatively new use of many composite materials is due to the lack of consolidated experimental data related to some mechanical characteristics. The difficult availability of experimental data often discourages, in turn, the use of composite materials compared to the widely known traditional ones. It should be noted, however, that the usage initially limited to extreme applications, has been widely diffused with consequent cost reduction and refinement of knowledge and production techniques. This trend can be verified, in particular, in some sectors such as, for example, the nautical one or the sports one, especially the automotive sector. Composite materials mainly boast high strength and low weight, corrosion resistance and high durability. But they have as many disadvantages including low flame resistance and galvanic corrosion. For this reason, in the aeronautical - aerospace - automotive field, composite materials coupled with titanium are used. Titanium, in the case of coupling with another material, tends to shrink rather than oxidize. This feature makes titanium particularly suitable for coupling with composite materials. This result guarantees a better resistance to corrosion; for this reason, it is used for aircraft that have an operating environment that facilitates corrosion. Another feature of interest to titanium is the coefficient of linear thermal expansion, which is much lower than other metals (about half compared to copper); this coefficient is the most important in the case of coupling of a metallic element to another non-metallic one. Composite materials are also characterized by a very low coefficient of thermal expansion: this is a reason why titanium is further compatible with composite materials. The drawback of titanium is that it is very expensive, because it is difficult to extract and work, whose BuyToFly ratio is 20: 1. Furthermore, in the case of chip removal machining operation, the cutting takes place by overcoming the resistance of the material; but titanium has a breaking load of 1000 Mpa. Therefore, under high forces the titanium deforms. Then the titanium has a low heat transfer coefficient: during the cutting process, heat is generated and this heat is stagnated. Furthermore, titanium has a superficial wear mechanism called Galling: locally I have titanium which remains attached to the tool and then pulls to the tool and returns to the titanium. To obtain chip removal, the tools are made of pure metal. To work with titanium, hard metals and special coatings are used; these tools cost a lot and do not last long

All these disadvantages lead to the choice to abandon the titanium and focus on aluminum that has low weight and limited costs. The problem of coupling aluminum and carboresin is due to the galvanic coupling because the carbon has a very noble electrochemical behavior; approaching the composite to aluminum, not noble, I have the corrosion of aluminum itself.

The solution consists in creating an aluminum coating on the composite by means of Cold Spray that avoids the onset of electrochemical phenomena that generate galvanic coupling.
Cold spray (CS) is a process in which solid powders are accelerated in a de Laval nozzle toward a substrate. If the impact velocity exceeds a threshold value, particles endure plastic deformation and adhere to the surface. Different materials such as metals, ceramics, composites and polymers can be deposited using cold spray, creating a wealth of interesting opportunities towards harvesting particular properties. Cold spray is a novel and promising technology to obtain a surface coating.The purpose of the elaborate is to create an aluminum coating that allows the coupling of composite materials with other types of metals, besides titanium, going to solve the problems related to it. Furthermore, the realization of metal coatings is also dictated by the need of the aerospace industry to use composite materials even under high-temperature operating conditions without suffering a considerable loss of performance.
In fact, a composite material shows a strong degradation of its mechanical properties in the presence of high-temperature gradients. Furthermore, the metallization of composite materials through the CS process has promising application perspectives, such as surface decoration, coating on sealing or welding components (to improve sealing or weldability), electromagnetic shielding plate rather than alleviating problems of wear and erosion with a limited additional weight.
The main aims of this work is producing composite panels suitable for the deposition and the analyzing the aforementioned panels using a different number of deposition parameter combinations to investigate the feasibility of the process. Moreover the challenge is to bring the process in the industry 4.0 scenario by sensorizing the deposition head and using machine learning technology in order to further optimize the process.