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Simulating a laser induced shock wave to help understanding direct damage of aeronautic composite structures under lightning strikes

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Aircrafts' structures are exposed to the risk of being damaged during and after a lightning strike which is a multi-physical harsh and unpredictable natural event [1]. Extremely high current and high voltage pulses of few microseconds to few milliseconds generate Joule's effects and magnetic forces which both induce mechanical forces and surface explosion producing a significant mechanical shock [2]. Many Lightning Strike Protection (LSP) layers have been developed for the protection of composite structures, among which Expanded Copper Foils (ECF). Still the dependence of damage generation process and final extent in the composite panel on the LSP behaviour is complex to handle and not completely understood from lightning test campaigns. In particular the coating paint layer can disturb considerably surface and core damage generation depending of its thickness and adhesion strength. The presence of coating paint constraint the arc expansion and thus the distribution of current into the LSP and composite structure. In order to measure the adhesion strength of the LSP under high strain rates due to the different shock waves, a laser shock campaign has been done. But the measurement of the rear face velocities, which is necessary to compute the adhesion strength of the paint or at the ECF interfaces, was not possible during the tests. A 2D numerical simulation model has been developed to simulate the mechanical shock induced by the laser. The campaigns used different levels of fluency to locate the rupture at the chosen interface. Numerical simulations are used as a complementary virtual testing tool that gives insight into the chronology of wave propagations through the different interfaces while it is impossible to observe events during real tests. Results of the simulation show crossing shock waves through the composite interfaces are compared to post-mortem damage observations after tests to help analysing the laser shock tests and estimate the interface strengths.

REFERENCES

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