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THERMO-ELECTRIC SIMULATION OF LIGTHNING STRIKE ON COMPOSITE LAMINATES

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The use of composite laminates for primary aircraft structures like fuselage implies to take into account the lightning strike hazard. Lightning strike is a threat to both metallic or composite structures, and requires careful considerations from a certification standpoint. The main difference between metallic and composite materials lies in the poor conductivity properties of the latter. However only few public research activity has been devoted to the study of lightning direct effects on the integrity of carbon fibre reinforced polymers (CFRP) structures [1, 2, 3].

The loading due to a lightning strike is very complex. The structure is submitted to (i) strong electric currents resulting in resistive heating due to Joule effect, (ii) severe direct heating due to the plasma channel and (iii) hydrodynamic pressure also due to the plasma. The aim of this study is to propose a comprehension model of the thermo-electric phenomena taking place and focusing on the resulting damaging pyrolysis. Nor transient structural dynamic response nor "mechanical" damage phenomena are taken into account in this early work.

Recent studies at Onera led to the developement of a magneto-hydrodynamic model in order to simulate the lightning channel [1]. The output of this model (direct heating and electric current) can be used as boundary conditions in the present finite element (FE) simulations. Pyrolysis is a very important damaging mechanism that affects thermal and electric conductivities as well as mechanical properties. Pyrolysis is driven by (i) dielectric breakdown due to high electric fields and conductivity anisotropy and (ii) volumic severe heating. A coupling between electrical current distribution and heat conduction can therefore be exhibited. A simple breakdown law as well as a heating degradation law are respectively introduced within non-linear electrostatic and heat transfert FE models. A coupling algorithm between these models is proposed to account for the physical thermo-electrical coupling.

Qualitative results are presented to illustrate the importance of taking into account the pyrolysis in this kind of simulations (cf. figure 1). This work is expected to be a prior stage before the achievement of a full electro-thermal-mechanical model.

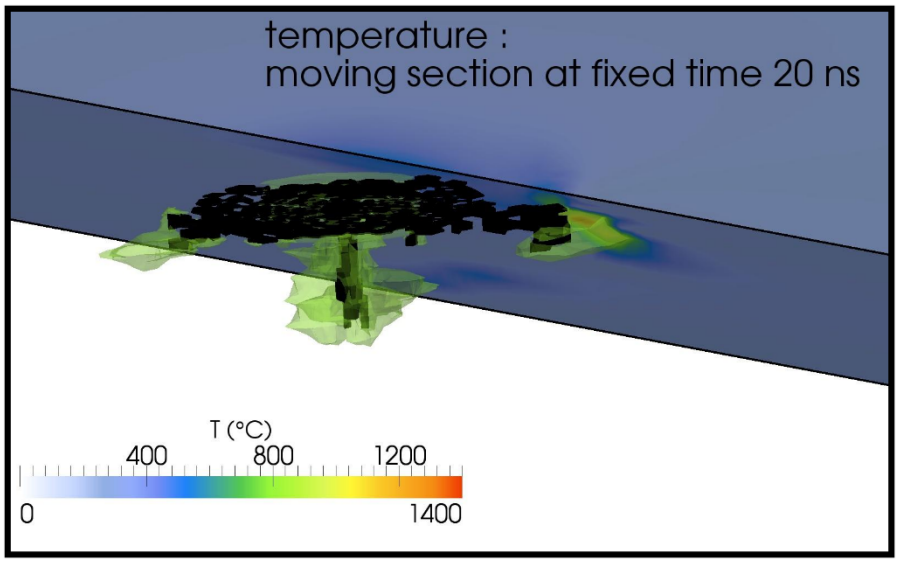

Figure 1: Temperature field and breakdowned material (in black) : section of a 8 plies composite laminate plate.

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