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Title

3D Modeling of an arc in interaction with composite materials

Authors

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Abstract

During the lightning strike on an aircraft and particularly in the pulsed arc phase, the current can reach values in the range of 200 kA during microsecond timescale. The direct effect of such arcs on structures can be quite severe depending on the material being used. This effect is even more troublesome on new composite materials used in modern airplane such as such as multilayer CFRP (Carbon Fiber Reinforced Polymer). Indeed, due to the highly anisotropic properties of CFRP composites, the electrical conductivity of composites is not scalar as in metallic materials but is generally tensorial. In a multilayer CFRP, each layer exhibits an electrical conductivity at least two order of magnitude higher in the direction of the fibers than in the direction perpendicular to it. Moreover, the different layers have different orientations of the fibers, and the transverse conductivity between them may be three or four orders of magnitude lower than the conductivity of the fibers. For the numerical study of an arc in the pulsed phase interacting with CFRP composite materials then requires to perform 3D simulations.

But such 3D computations are very expensive and require the use of very fine meshes with at least 100 million of cells. In order to do these simulations in a reasonable amount of time, access to at least few thousands of CPUs is mandatory. One way to decrease the resources needed for these demanding 3D simulations is to have a mesh that adapts itself in time and space to the characteristic physical scales. Following this idea, the MHD 2D/3D code Taranis developed at ONERA has been coupled with Feflo.a [1], the anisotropic mesh refinement code developed at INRIA. This new numerical framework allows to carry out very demanding 3D computations at a fraction of the cost of computations using fixed meshes.

After the presentation of the code Taranis and the MHD model, this new Taranis/Feflo.a framework will be presented with some examples. In the second part of this work, a 3D numerical study showing the effect of different materials on the dynamics of an arc in the pulsed phase will be detailed. In the last part, a comparison with experimental results obtain on the Grifon facility will be presented.

References

[1] : Alauzet, F., & Frazza, L. (2021). Feature-based and goal-oriented anisotropic mesh adaptation for RANS applications in aeronautics and aerospace. Journal of Computational Physics, 439, 110340.