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2D AND 3D NUMERICAL SIMULATIONS OF DAMAGE DURING THE FORMATION OF SUCCESSIVE CHIPS WHEN MACHINING THE AERONAUTICAL CFRP COMPOSITES

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A finite element method has been developed to simulate the cutting process of composites containing long carbon fibers and polymer matrix (CFRP composites). A complete mechanical approach has been performed coupling the damage-elastoplastic behavior and stiffness degradation of the composite properties. Moreover, the plasticity caused by permanent deformation, fiber-matrix debonding and matrix cracking has been taken into account. In this work, a unidirectional ply was studied using a meso-scale modelling of damages in composites.

The proposed approach is primarily focused on the understanding of interactions between the fiber orientation, machining process and the physical phenomena governing the chip formation process.

The analysis of the chip formation, cutting forces and the induced damage has been done through 2D and 3D simulations, see Figure 1. A VUMAT subroutine, providing the capability for implementing elastoplastic damage models has been used in Abaqus/Explicit. A damage variable has been calculated for each type of damage that appears in the workpiece: fiber breaking, matrix cracking and fiber-matrix debonding.

Satisfactory numerical results have been obtained on an orthogonal cutting application and a good correlation has been found with experimental results, [1,2].

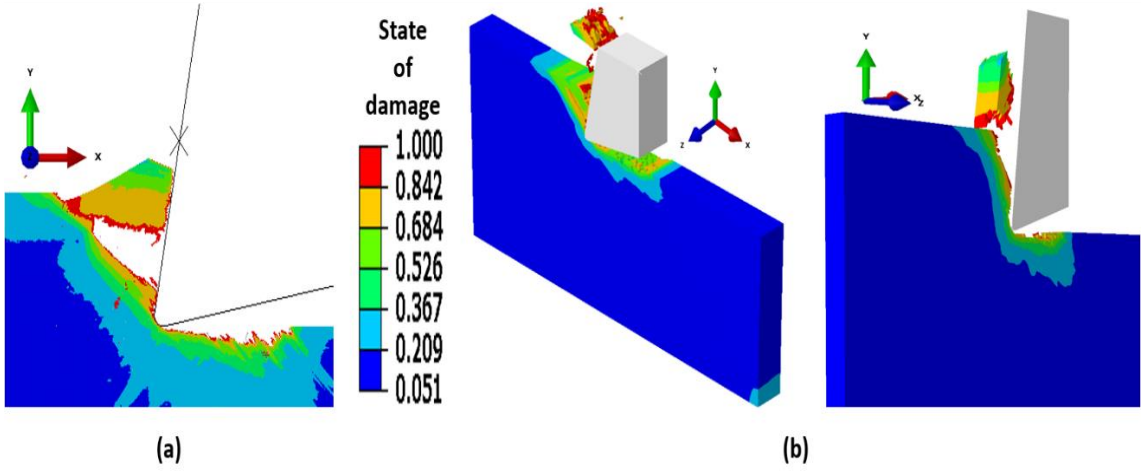

Figure1. Numerical simulation of the chip formation with (a)- 2D formulation and (b)- 3D formulation. The simulations clearly show the initiation and damage growth generated during the chip formation process.

REFERENCES

[1] Iliescu, D., Gehin, D., Iordanoff, I., Girot, F., Gutiérrez, M.E, A discrete element method for the simulation of CFRP cutting, *Compos Sci Technol* 70 (1) (2010), pp. 73–80

[2] Wang, D. H., Ramulu, M., Arola D., Orthogonal cutting mechanisms of graphite/epoxy composite. Part I: Unidirectional Laminate, *International Journal of Machine Tools and Manufacture*, 35 (12), pp 1623-1638, 1995.