

Coupled Euler Lagrangian Approach Using Abaqus /Explicit in the Bird Strike Aircraft Damage Analysis

I. Smojver and D. Ivančević

Department of Aeronautical Engineering, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb

I. Lučića 5, HR-10000, Zagreb, Croatia

Abstract: Bird impact damage in complex aircraft structure has been investigated using explicit transient dynamic analysis by Abaqus/Explicit in order to fully employ its large library of elements, material models and the ability of implementing user defined materials. The numerical procedure has been applied on the very detailed large airplane secondary structure consisting of sandwich, composite and metallic structural items that have been modeled with 3D, shell and continuum shell elements, coupled with appropriate kinematic constraints. Bird has been modeled using Coupled Euler Lagrangian approach, in order to avoid the numerical difficulties connected with the mesh. The impact has been applied in the area that is the most probably subjected to the impact damage during the exploitation. The application point and velocity vector have been varied and the comparisons between total, kinetic, internal and damage energies have been performed. Various failure modes, such as CFRP face layer rupture, failure of composite matrix, damage initiation / evolution in the Nomex core and elastoplastic failure of a metallic structure have been investigated. Besides, general contact has been applied as to efficiently capture the contact between impactor and structure, as well as large deformations of the different structural components. Visualization of failure modes has been performed and damaged area compared to the available references. Compared to the classic Lagrangian modeling of the bird, the analysis has proven to be more stable, and the results, such as and damage areas, physically more realistic.

Keywords: Airplane structures, Composites, Bird strike, Impact damage, Coupled Eulerian Lagrangian analysis, Contact, High lift devices, Abaqus/Explicit.

List of used symbols:

\mathbf{C}_d - elasticity matrix including damage

E_1, E_2 – Young's moduli in the fiber and transverse direction, respectively

d_f, d_m, d_s - fiber, matrix and shear damage parameters, respectively

G_{12} - shear modulus

δ_{eq} - equivalent displacement

δ_{eq}^0 - equivalent displacement at which Hashin's failure criterion has been reached

δ_{eq}^f - equivalent displacement at which the material is completely degraded