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HIGH-VELOCITY IMPACTS ON AEROSPACE THIN COMPOSITE LAMINATES

Consuelo Terra, Michele Pasquali, Paolo Gaudenzi

Department of Mechanical and Aerospace Engineering, University of Rome, La Sapienza, Italy
terra.consuelo@gmail.com ; michele.pasquali@uniroma1.it ; paolo.gaudenzi@uniroma1.it

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Summary: Even though polymer matrix composites generally possess high specific stiffness and high specific strength, they feature a reduced ability to absorb impact energy. Structures subjected to high velocity impacts (HVI), therefore, are likely to suffer complete perforation, which, in the aerospace field, can lead to the dramatic failure of the overall structural system. The effective use of composite materials in structural aerospace applications is thus critically affected by the capability of ascertaining their performances when subjected to impacts.
In this work, an analytical formulation aimed at estimating the ballistic limit of thin composite targets given their mechanical and geometric properties, as well as the projectile shape and initial velocity, is proposed. The described approach, in particular, takes into account two-dimensional woven fabric composites and it is based on wave propagation theory. In the impact event, an energy transfer from the projectile to the target takes place. The kinetic energy of the projectile is either absorbed or dissipated by the composite laminate via various deformation\damage mechanisms. Among them, (i) the tensile deformation of the yarns lying in the area of the impact (primary yarns); (ii) the deformation of yarns constituting the region surrounding the impacted zone (secondary yarns); (iii) the delamination onset and propagation and (iv) the matrix cracking play a critical role. Additionally, while thin and flexible composites show a conical deformation on the back face of the target with kinetic energy associated to the moving cone, thick and rigid composites are mainly affected by shear plugging. Here, in particular, an innovative formulation to describe the effects associated to the shear plugging is developed. Finally, the ballistic limit, the damage size and the impact duration are obtained through enforcement of the energy balance. A validation of the proposed formulation is achieved resorting to an experimental campaign as well as to literature results. The obtained numerical predictions are found to be in good agreement with the experimental data.