Determination of the constitutive relations of ceramic and ceramic-like brittle materials for the simulations of impact events

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Abstract

So-called integrated armor is mainly composed of a hard front ceramic layer (Al_2O_3, SiC and B_4C) and a ductile backing layer of a metal (Al, 4340 steel, Ti64) or a fiber reinforced composite plate (i.e. glass fiber reinforced epoxy and vinyl ester). A metal cover plate or a metal buffer is usually inserted at the front of the ceramic layer in order to mitigate the stress wave propagation through the ceramic layer, and an interface compliant layer such as rubber or aluminum foam is inserted to reduce the impulse transferred to the continuous backing layer. The numerical simulation of this multilayered structure, composing of the layers of ceramic, metal, polymer and composite, is challenging and requires the use of constitutive relations showing correct material response at increasingly high strain rates. In this presentation, the commonly used constitutive equations for metals, composites and ceramics will be shortly explained. The experimental methods of the constitutive equation parameter determination will be explained and particular emphasis will be directed on the Johnson Holmquist damage model-1(JH-1) and Johnson Holmquist damage model-2 (JH-2) models which are commonly used to define the stress and damage models of ceramics. The examples of the simulations with the use of JH-1 and JH-2 models will be shown for an integrated armor with an alumina ceramic front layer and a woven fabric glass fiber polyester composite backing plate. The effect of interface rubber and aluminum foam layers will be also discussed based on the simulation results. Finally, the new developments in the integrated ceramic armors will be shown with a historical background in the light of a recent literature survey on the subject.