11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Multi-scale Modeling of Shockwave Interaction with Thin Layer Strain Rate Sensitive Polymers

Roshdy G. Barsoum
Office of Naval Research, Arlington, VA, USA, **Roshdy.Barsoum@NAVY.MIL**

Key Words: multi-scale, modelling, elastomers, strain rate sensitive polymers, shockwave. coupled media

Recent investigations into Explosion Resistant Coating elastomeric polymers, which exhibit high rate sensitivity properties, indicate that they can dissipate broad bands of frequencies such as those encountered in blast events (1). These elastomeric polymers, in addition to their visco-plastic behavior, are multi-phase, at the nano scale they consist of hard segments and soft matrix. To understand and elucidate this nano-micro –to-continuum behavior, multi scale computations are extensively used. These polymers also interact with underlying substrates in a complex coupling of wave propagation and large nonlinear deformation and localization, which have been shown to absorb shock in quite a different manner than any ballistic material known to the armor community (2).

ONR is leading a Basic Research Challenge to develop polymers-by-design to divert and dissipate shockwaves from the head and thus prevent mild Traumatic Brain Injury - mTBI(3-5). Molecular dynamics--coarse scale modeling, are used to optimize the polymer properties and predict effect of nano-scale structure on continuum and high rate constitutive behavior. Coupled continuum modeling, high rate load, and multi-scale continuum XFEM modeling (3) feed the results to large scale coupled computations using bio-high fidelity models of the head and brain are used in this investigation (5). In this presentation we will focus on efforts related to designing new polymers (3, 4) using multi-scale modeling of coupled media associated with air blast shockwave propagation in strain rate sensitive polymers, composite materials/interfaces, air and the head/brain (skin, skull, gaps, cerebral fluid and brain tissue) (5). The polymers of interest are highly strain rate sensitive with complex constitutive behavior, and inclusions (particles, from the nano- to micro-scale) which could dissipate and divert the shockwave. To understand interaction between materials and wave propagation at extreme high rate requires multi-scale coupled computations are addressed at different spatial and temporal scales.

REFERENCES

[1] R. Barsoum *"Elastomeric Polymers for Shockwave Mitigation and Extreme Loading Conditions", SEMXII,* Challenges in Mechanics of Time-Dependent Materials Conference Experimental and Applied Mechanics, Costa Mesa, CA, June 11-14, 2012.
[2] R. Barsoum and P. Dudt, *"The Fascinating behavior of ordinary materials under dynamic conditions"* , AMPTIAC, V.4, No. 4, 2009.
[3] S. Nemat-Nasser, *"Elastomeric Polymer By-Design for Blast induced Shack wave Management"*, UCSD Review , ONR, OCT 30, 2013.
[4] J. Runt, *"Elastomeric Polymer-by-Design to Protect the warfighter against Traumatic Brain Injury"* PSU Review, ONR, OCT 30, 2013.
[5] R. Radovitzky *"Large scale simulation of polymer-by-design systems for blast-induced TBI mitigation"*, R. , MIT, ONR, OCT 30, 2013.