Stress Attenuation by Means of Particulates and Inclusions

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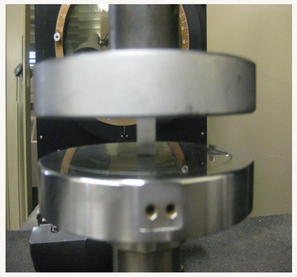
Abstract

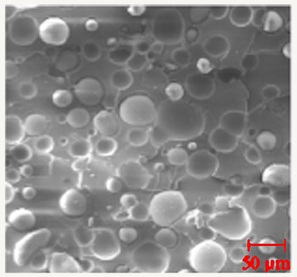
The goal of the research is to investigate materials with potential uses as shields in highly dynamic environment. The materials are loaded at various strain rates ranging from 10^{-2} to 10^{5} s^{-1}. As the wave propagates, we analyze the modes of failure, and the gradual progression of stresses during the event. Particular attention is paid to the attenuating characteristics of those materials, with the goal of identifying configurations and modifications that will suppress dynamic waves.

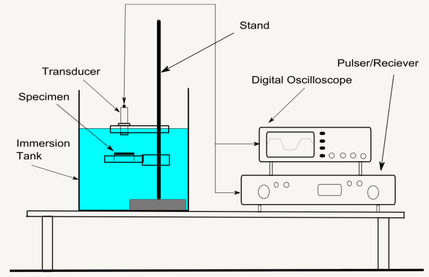
Relevance

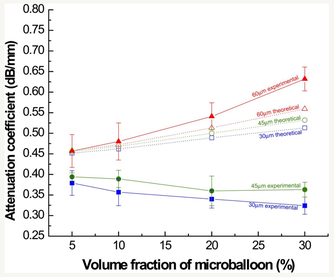
Numerous theories pertaining to wave scattering in materials containing particulates have not been fully validated, since interfacial impedance mismatch results in partial absorption, refraction, and reflection. Further, the wave must labor through a tortuous path to reach the side directly opposite the energetic application. Within a certain range, the increasing presence of pores in a material is predicted to monotonically increase wave attenuation. However, the experiments show this to be true only beyond certain pore sizes, while complex interaction present with smaller pores have the opposite deteriorating effect. These observations can be applied directly to shielding material design.

Technical Approach

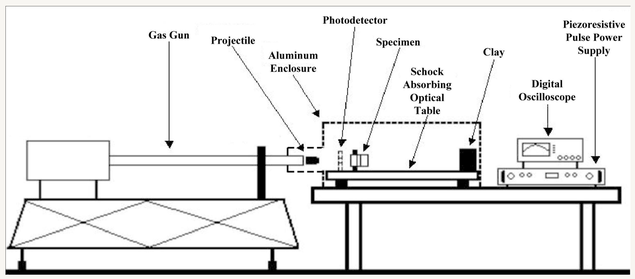


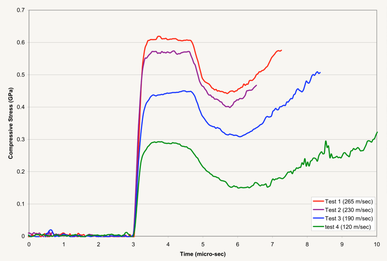


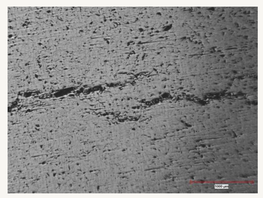




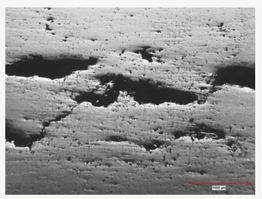
Full characterization of syntactic foam used in shielding applications.
Dynamic attenuation of the material is sought and compared to theoretical predictions



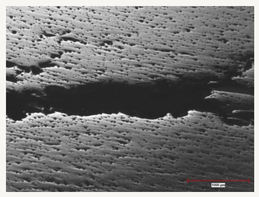




Onset of failure



Progressive failure



Severe failure

Impactor used to generate dynamic failure due to shock wave propagation. Lower and upper bounds generating partial to full failure are found.

Accomplishments Through Current Year

We have fully implemented a new vacuum chamber for our impact experiments, with new fixtures that achieve near-ideal planarity of impact. We have also completing a study on the attenuating characteristics of syntactic foams. The behavior of these materials is highly dependent of pore size and concentration.

Future Work

We will continue with the investigation of non-hollow particulates, structural materials, and other shielding materials. We have initiated the acquisition of equipment to complete the building and implementation of a doppler velocimeter for capturing particle velocity.

Opportunities for Transition to Customer

Former research opportunities have resulted in close contact with local industries, some with DoD associations, that have provided us materials, particularly fiber-glass/polymeric-based composites, for evaluation. We will reinitiate these interactions and investigate their materials in light of this research, and explore their effectiveness as stress attenuators. Such results will be beneficial to those companies, allowing then to gain new knowledge of and potential uses for their materials.

Publications Acknowledging DHS Support

Rousseau, C.-E., Chalivendra, V., Tiipur, H. V., Shukla, A, "Experimental fracture mechanics of functionally graded materials: an overview of optical investigations", Experimental Mechanics, 2010.

B. Ale, & C.-E. Rousseau 2011, "Dynamic attenuation properties of syntactic foams," Int. J. Polymer Science, submitted. Under review, 2011.

Other References

B. Ale, & C.-E. Rousseau, 2010, "Dynamic attenuation properties of syntactic foams," IMPLAST 2010, Providence, RI.

G. Plume, & C.-E. Rousseau 2010, "A preliminary investigation into the spall strength of cast iron," IMPLAST 2010, Providence, RI.

W. Visser, G. Plume, C.-E. Rousseau, & H. Ghonem 2010, "Deformation criterion of low carbon steel subjected to high speed impacts," IMPLAST 2010, Providence,

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