Symposium Preview: High Strain Rate Behaviors of Composites and Heterogeneous Materials

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INTRODUCTION

The applications of composite materials are rapidly increasing and the usage is now over 8 million tons/year. In a significant advancement, composite materials comprise over 40% by weight in some modern civilian and military aircraft. In addition to aerospace structures, composites are extensively used in the automotive and sports industries. These applications require development of new composite materials with higher performance and safety standards along with better understanding of their deformation and fracture behavior under quasi-static and dynamic loading conditions. Available experimental and theoretical studies have demonstrated that the mechanical properties and failure behavior of composite materials are strain rate dependent. Therefore, correlating the material behavior with varying high strain rate, ballistic, blast, and impact loading conditions is of immense interest in these applications. This knowledge will enable design of composites specific to the application and loading condition.

Use of the split-Hopkinson pressure bar is among one of the most common methods for testing materials at high strain rates. In this method an elastic wave traveling inside a solid medium is transferred to the specimen, which can lead to strain rates in the range of $10^6$–$10^7$/s. In addition, subjecting specimens to blast waves is increasingly being used as a high strain rate testing method. Constituent materials, microstructure, and composition are known to influence the high strain rate behavior of composite materials. The current focus of the materials research in this area can be summarized as: to understand the interaction of impulsive loading with constituent materials, interfaces, and porosity present in advanced composites; to establish the deformation and failure mechanisms at high strain rates; and to design materials with microstructures that are effective in energy absorption and damage localization. An example of transition in material failure mechanism with increasing strain rate for hollow particle filled polymer matrix composites is shown in Figure 1. At lower strain rate the specimen fractures by initiation of shear cracks, whereas at higher strain rate a crushed surface layer is observed with cracks along the loading direction. Such transition in dynamic fracture behavior is accompanied with changes in the modulus, strength, and energy absorption.

HIGH STRAIN RATE BEHAVIOR RESEARCH: APPLICATIONS

Ballistic Protection and Blast-Resistant Materials

Development of a protective material that is effective both for ballistic and blast loading is an important goal for the military and a major challenge for scientists. Although effective ballistic protection materials have been developed, the same materials may not be effective in mitigating blast waves. An available review details the differences in material failure under blast loading conditions. Understanding the shock mitigation mechanism in materials and designing new composite materials effective against shock loading conditions will enable the development of lightweight ballistic protection and blast-resistant materials.

Design of Safer Structures and Infrastructure

Composite materials are increasingly used in aircraft, ships, and buildings. Composite materials are also used to repair aging infrastructure, such as bridges, made of traditional building materials. Ongoing research on high strain rate and blast performance of composites can help in designing structures that are safe under such loading conditions.

Explosive Forming

One of the areas where high strain
rate loading conditions have been beneficially utilized in metal forming. Various components made from alloys of aluminum, copper, and iron are manufactured using explosive forming techniques.\textsuperscript{4} Such methods can provide advantages due to very fast processing, including the possibility of forming reactive phases and obtaining ultrafine grain size.\textsuperscript{5} However, fabrication of composites using these techniques presents new challenges because the presence of reinforcement activates new deformation and failure mechanisms, which need to be understood.

**Biomaterials and Medical Applications**

Researchers working with biomaterials and in medical fields are increasingly interested in understanding the interaction of shock waves with materials such as bone and soft tissue.\textsuperscript{6} Such understanding will help injured personnel and trauma victims through the development of better clinical practices for treatment.\textsuperscript{7} Establishment of a standardized shock test method, availability of test guidelines, and availability of detailed studies will help engineers, doctors, and the military in developing new and more effective diagnostic tools and clinical methods.

**SYMPOSIUM PLAN**

To facilitate interdisciplinary interaction and bring together academic, industry, and government researchers focused on high strain rate deformation phenomena, a symposium is planned for the Materials Science and Technology 2010 conference. The conference will be held at the George R. Brown Convention Center in Houston, Texas, October 17–21, 2010. The symposium will focus on exploring strain rate dependence of composites and other heterogeneous materials and will provide a forum to discuss the recent advances made through

- Experimental investigations on high strain rate response of polymer/metal/ceramic matrix composites
- Experimental investigations on high strain rate response of natural/bio/soft materials
- Other dynamic conditions such as ballistic or blast loading of materials
- Modeling and simulation studies

The symposium will feature three keynote presentations and several invited and contributed presentations. Abstracts can be submitted through the conference website www.program-master.org/MST10. For any additional information please contact the symposium organizers Kyu Cho and Nikhil Gupta (contact information provided at the end of this article).

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**References**


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