Tensile Hopkinson Bar Testing of Plastic Films at High Strain Rates

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Material properties during high strain rate tensile loading in plastic films will be investigated. Experiments will be performed by sending pulses through plastic films and measuring the stress, strain and time responses in the films. Equations will be developed to relate the strain rate and the material properties.

The objective is to experimentally find the mechanical properties of a plastic film versus the strain rate. A Hopkinson bar will be used to generate tension pulses and to transmitt the pulses into the film specimens. The plastic films will be tested at strain rates in the dynamic range of approximately 1000 unit strains per second and above. Equations governing the material properties and strain rates will be formed. Results will be given in a form that will assist in designing dynamic processes with plastic films.

Material behavior can change dramatically at high strain rates making traditional material properties based on static loading incorrect. Experiments have found that materials undergoing a high strain rate show an increase in the modulus of elasticity and a decrease in toughness (Al-Mousawi, Reid and Deans, 1997). Compressive testing of silicon rubber by Chen, Zhang and Forrestal (1999) found a significant increase in the modulus of elasticity occured between static and dynamic loading. Dynamic loading commonly occurs in manufacturing processes and known material behavior is needed to properly design equipment and processes.

The plastic films will be tested at high strain rates by using a split Hopkinson tension bar as given in Sierakowski (1997). The Hopkinson bar consists of two bars, incident and transmission, joined axially by the film specimen to be tested. A high velocity projectile will impact the free end of the incident bar creating a tension pulse. At the junction of the incident bar and the film specimen, the pulse is partially reflected back into the incident bar and partially transmitted into the film specimen. Similarly, the pulse travels into the transmission bar from the film specimen. Strain gages located on the incident and transmission bars will record the local strains as the reflected or transmitted pulses pass. The magnitudes and timings of the pulses determine the strain and strain rates in the film specimens. The strain and time data collected will be used to formulate stress and modulus of elasticity relations as a function of the strain rate.

This project will investigate and quantify the mechanical properties of a plastic film at high strain rates. Equations describing the effective modulus of elasticity and stress versus the strain rate will be developed. The results will assist the optimization of dynamic manufacturing processing of plastic films.

Al-Mousawi, M. M., Reid, S. R. and Deans, W. F. The use of the split Hopkinson pressure bar techniques in high strain rate materials testing. *Proc. Instn. Mech. Engrs.* **211**:273-292, 1997.

Chen, W., Zhang, B. and Forrestal, M. J. A Split Hopkinson Bar Technique for Low-impedance Materials. *Experimental Mechanics* **39**:81-85, June 1999.

Sierakowski, Robert L. and Chaturvedi, Chive K. *Dynamic Loading and characterization of fiber-reinforced composites.* John Wiley & Sons, 1997.