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Testing of ACC-6 Carbon-Carbon at High Strain Rates and High Temperatures

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Abstract

Some materials, such as steel, titanium, and tungsten, have a yield stress that depends on the strain rate, and actually are stronger at high rates of load or deformation. The increase in strength is relevant; and if not taken into account, the computer models will not match the experimental behavior observed in typical shock loading, ordnance, or ballistic tests. For higher velocity (hypervelocity impacts), an equation of state that accounts for non-linearities and temperature in the pressure-volume relation, may also be needed.

This rate-dependent behavior of the strength has also been observed in some composite materials. Southwest Research Institute® (SwRI®) has started an internal research effort to measure and better model the behavior of materials, in particular carbon/carbon composites like ACC-6, at ultra-high temperatures for both static and high rates of deformation. The ultimate objective is to obtain reliable computer models of carbon/carbon material under hypersonic flight conditions, hypervelocity impacts, shock-loading situations such as booster-vehicle separation, and munition operation events. SwRI® has successfully modeled in the past ballistic impact on other composites, namely S-2 glass/epoxy, Kevlar/resin, polyethylene fibers/resin, and carbon fiber composites.

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This presentation will show test results relevant to the strength properties of the ACC-6 C/C material which were measured at quasistatic, medium, and the moderately high strain rates (~10^3 s^{-1}) achievable in a conventional Split Hopkinson bar apparatus. Some of the tests were performed at both high-rates and high temperatures typical of hypersonic flight, something that, to the authors' knowledge, has never been published in the past for this particular material.

The test method will be presented, as well as the comparison of the stress-strain curves for the different temperatures and strain-rates of interest. A discussion of how the results can be used in the typical hydrocodes of interest will be included.

Outline

- Objectives of the Internal Research
- Experimental Set-up
- Challenges in testing composite materials at high strain-rates.
- Challenges in testing composite materials at high temperatures and high strain-rates.
- Relevant results
- Comments and conclusions