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Strain-rate-dependent response of an alumina ceramic under compressive and compression-shear loading

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ABSTRACT

This presentation will show the results on the stress-state and strain-rate dependent mechanical properties and failure of the CeramTec 96% alumina ceramic under uniaxial compression and compression-shear loadings. The uniaxial compressive strength of the material was found to be 2977 to 3691 MPa at strain rates of 10^{-5} to 10^{-3} s^{-1} and 3763 to 4645 MPa at strain rates of 10^{2} to 10^{3} s^{-1}, which was higher than some other commercially available alumina ceramics (e.g., AD-995) from the literature. During testing, high-speed imaging coupled with digital image correlation (DIC) was used to capture the deformation process and obtain strain field information. After that, a new data processing method was proposed in this study to calculate the shear stress and strain for the compression-shear tests. Subsequently, this method was validated by comparing the shear strain profile obtained from the DIC analysis. Using the results obtained by the proposed model and the DIC analysis, new observations and understanding of the stress-state and strain-rate dependent failure mechanisms are obtained: 1) there exists directional-cracking-induced anisotropic damage evolution for the CeramTec 96% alumina ceramic. The directional cracks have weak influence on the compressive stiffness, but have a strong influence on the shear response, and 2) when failure reached, the damage evolution is non-linear. These new mechanisms will be implemented into a hybrid finite-discrete element model to describe fracture and fragmentation processes that manifest during dynamic failure of advanced ceramics, whose preliminary results will be discussed in this presentation.