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Rate & Microstructure Influence on Fracture of WC-Co/Ni Composites[1]

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Tungsten carbide metal matrix composites contain ceramic grains of tungsten carbide within a binder of cobalt (Co) or nickel (Ni), allowing the material to have advantageous properties of both metals and ceramics including higher resistance to fracture than most structural ceramics, and higher resistance to permanent deformation than most engineering metals [3]. Due to these performance advantages, WC composites are of interest in drilling, manufacturing tools, and defense penetrator applications, to name a few. Under quasi-static conditions, these hardmetals have been shown to generally exhibit an increase in fracture toughness with an increase in mean free path in the binder phase, and an increase in hardness and wear resistance with a decrease in WC grain size [4]; yet relatively little is known in regards to their dynamic response. Here we present the fracture behavior of WC metal matrix composites under three extreme loading conditions: (1) a single-strike acceleration loading to characterize classical dynamic crack tip energetics via stress intensity factors (SIFs) (2) the impact fatigue, or sub-catastrophic repetitive strikes to failure, and (3) the dynamic crack interactions with normal impact over 1 km/s using an in-house combustionless two-stage light-gas gun. All investigations are conducted using ultra high-speed imaging with full-field measurements from digital image correlation (DIC), and post-mortem scanning electron microscopy. Preliminary results for (1) show that the dynamic fracture toughness increases by a factor of 1.22 to 1.65 over quasi-static, regardless of the binder or grain size investigated.

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[2]In collaboration with L. Shannahan, G. Retuerta, P. Jewell, and S. Pagano of Drexel University
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