Comparison of Wear Between Intermetallic-Bonded Diamond, WC and PDC

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Abstract

Commercially available Polycrystalline Diamond Compact (PDC) and high impact grade commercial WC were used for comparison of performance with the newly developed intermetallic bonded diamond composite (IBD) prepared at Southern Illinois University Carbondale (SIU). The wear and impact tests were designed with respect to the current capacity available at SIU and are different from wear and impact tests generally used by industry. Although, the generic IBD tools were not optimized, they considerably out performed commercial WC and PDC tools in impact type wear tests. All materials tested survived multiple impact energies of up to 125 J. The microstructure and properties of IBD's can be further improved and optimized to address specific applications.

Introduction

IBDs were invented at SIU and tests performed earlier in laboratories and coal mines indicated their performance was superior when compared to materials currently being used (based mostly on WC/Co). For the purpose of improving the knowledge base involving development of future IBD's and understanding failure mechanisms, the wear performance and impact resistance of commercial tools used in oil drill bits were compared with the current "standard" IBD formulation. The wear and impact tests performed were designed with respect to the current technologies available at SIUC.

Experimental

Wear tests (smooth and impact) and impact/drop tests were performed on 10 commercial PDC, 5 commercial WC, and 6 "standard" IBD samples. Wear tests were performed using the Friction Assessment and Screening Tester (FAST) seen in Figure 1. Two types of wear discs were used: granite (G) and cast iron (CI). Flat discs rendered "smooth wear" and special discs rendered "impact wear" conditions. Special holders positioned samples at 19° with respect to the opposing counterface.

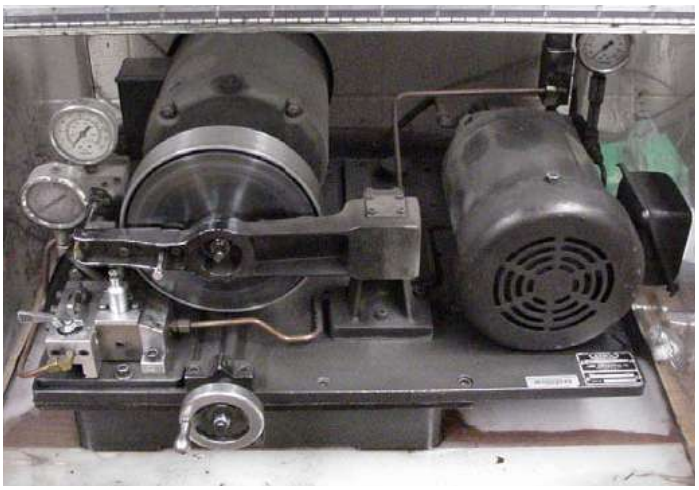

Figure 1. FAST test apparatus.

Impact tests (drop tests) were performed at room temperature using the "in-house made" impactor . A dead mass was impacted on the bit face inclined at 19° angle with respect to the impacting plane. Each impact/drop test was performed with a new steel tool insert with hardness between 60 and 62 HRC.

The speed of impacting cross-beam was measured by a high-speed camera. The amount of energy

absorbed was calculated from the differences between the original height and that after the first bounce.

Results and Discussion

Wear data obtained from the FAST test (Figures 2-4) indicated that the PDC samples wear slightly less than IBD and considerably less than WC, in the so called "smooth wear application" on granite or cast iron. However, in wear situations where impact was superimposed on the test materials (rough wearing with vibration impact), the IBD showed superior performance compared to both the PDC and WC.

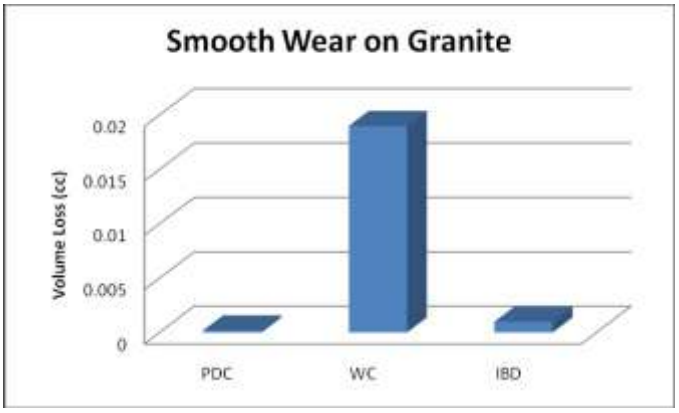

Figure 2. Results of smooth wear on granite.

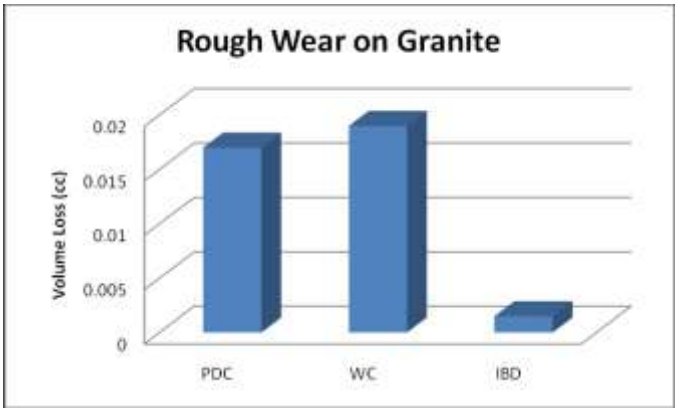

Figure 3. Results of rough wear on granite

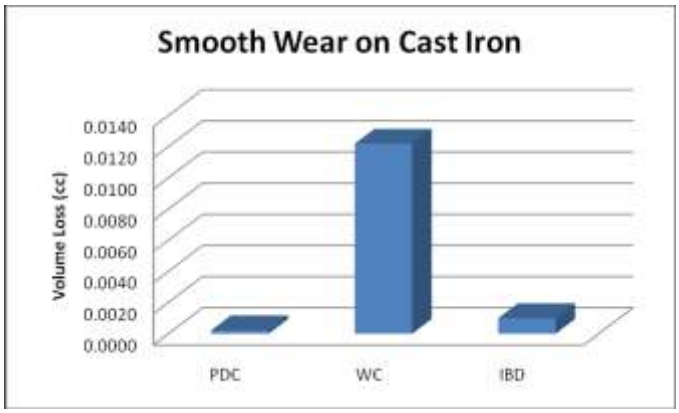

Figure 4. Results of smooth wear on cast iron

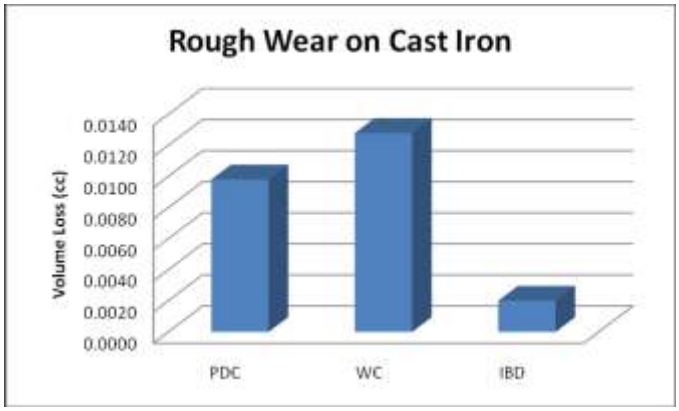

Figure 5. Results of rough wear on cast iron

Results from impact drop testing showed that all samples were able to sustain multiple impact energies of 125 J without failure. All materials showed signs of plastic deformation.

Conclusions

- In "impact wear" simulations the IBD showed superior performance when compared to both PDC and WC with the WC exhibiting the worst performance
- Preliminary impact tests revealed that all materials sustained impact of energies of 125 J with signs of plastic deformation.