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Impact Resistance of Intermetallic Bonded Diamond Composites and Polycrystalline Diamond Compacts

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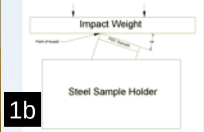
Introduction

Intermetallic-Bonded Diamond Composite (IBD), developed at Southern Illinois University (SIU), is a ground-breaking new material with potential in the drilling and machining industry. In previous work, IBD was found to exceed high standards of hardness and wear resistance, however, there is no detailed record of IBD friction and wear performance or impact resistance compared with polycrystalline diamond (PDC), one of today's leading materials used in industry for high-wear applications.

Experimental Procedure

1a

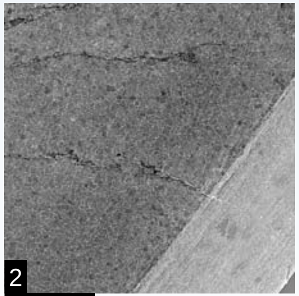
In order to test the impact resistance of six PDC samples, the CAFS in house impact tester was used. Figure 1a shows the impact tester, and Figure 1b shows a schematic drawing of the sample position in the steel fixture. A drop-mass of 21.2 kg was used. The height of the cross piece was adjusted on each test to reach the desired initial gravitational potential energy. A high speed camera was used to capture the drop load rebound height after impact in order to find the final potential energy. The difference between initial and final potential energy is the energy absorbed by the sample. See equation below:



1b

Energy Absorbed = mg(h1-h2)

Results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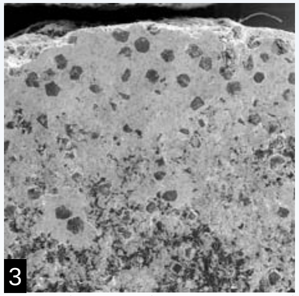
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Table 1

Run #	Mass (kg)	Height (m)	Initial PE (J)	Bounce (m)	Final PE (J)	Energy Absorbed (J)
PDC Sample #9						
1	21.2	0.48	100	0.05	10.4	89.6
2	21.2	0.51	105	0.06	11.4	93.6
3	21.2	0.53	110	0.08	16.1	93.9
4	21.2	0.55	115	0.06	11.4	103.6
5	21.2	0.58	120	0.06	11.4	108.6 (Fracture)
PDC Sample #10						
1	21.2	0.58	120	0.05	10.4	109.6
2	21.2	0.61	125	0.06	12.5	112.5
3	21.2	0.61	125	0.06	12.5	112.5 (Fracture)
PDC Sample #11						
1	21.2	0.61	125	0.05	10.4	114.6
2	21.2	0.61	125	0.06	11.4	113.6
3	21.2	0.61	125	0.05	10.4	114.6
4	21.2	0.61	125	0.06	11.4	113.6
5	21.2	0.61	125	0.06	11.4	113.6 (Fracture)
IBD Samples (Each sample impacted once with 125 J.)						
#1	21.2	0.61	125	0.06	12.5	112.5
#2	21.2	0.61	125	0.05	10.4	114.6
#3	21.2	0.61	125	0.06	13.1	111.9
#4	21.2	0.61	125	0.06	11.4	113.6
#5	21.2	0.61	125	0.06	11.9	113.3 (Fracture)

Figure 2 shows the impacted surface of a PDC sample. These induced fractres travel across the entire sample and sink deep into the surface.

Figure 3 is a tested IBD sample under 125 J. load. The impacted edge is plastically deformed, appearing smooth, while the lower half of the sample remains rough.

Table 1 displays a set of impact test data. PDC samples were tested until failure around 125 J. Each IBD sample was impacted once at 125 J.

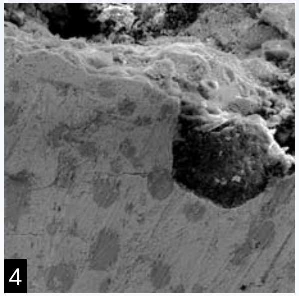
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Figure 4 is a highly magnified image of an impacted IBD sample. This image shows how the surface fractured transcrystalline and also how a diamond particle was pushed deeper into the nickel aluminide binder due to the samples unpolished surface. There are also micro latent cracks seen in the binder.

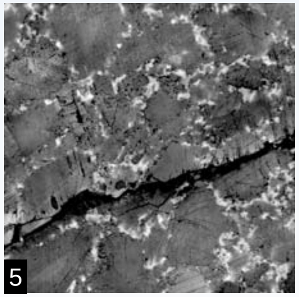
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Figure 5 shows the surface fracture mechanisms of a PDC sample. This fracture travels transcrystalline, through the diamonds, instead of along the grain boundaries. The cobalt-tungsten binder deforms plastically but stays strong. Several micro cracks can be seen in the grains as well.

Conclusions & Future Work

-IBD outperforms PDC in toughness testing and impact resistance applications.

-Fractures in PDC samples tend to travel transcrystalline while the cobalt-tungsten binder deforms plastically.

-Intermetallic binder of IBD deforms plastically with impact while some diamonds can be fractured.

-IBD breaking point levels are higher than PDC, which were within the 120-125 J. range, while absorbing an average of 112 J.

-Future research is needed to discover a method of polishing IBD samples for similar material sample surfaces during testing

-Future research is needed to hone in on a more accurate breaking point range for IBD.

References

Dr. Peter Filip and Dr. Dale Wittmer, "Wear Performance of IBD compared with Halliburton PDC and WC- Preliminary Results" SIU Carbondale CAFS: March 9, 2009

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