IMPROVEMENT OF WEAR COMPONENT'S PERFORMANCE BY UTILIZING ADVANCED MATERIALS AND NEW MANUFACTURING TECHNOLOGIES: CASTCON PROCESS FOR MINING APPLICATIONS

Quarterly Technical Progress Report

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Abstract and Summary

The project was highlighted by continued fabrication of drill bit inserts and testing them: 1) The inserts were subjected to hammer tests to determine brittleness. Selected inserts experienced multiple blows from a 16 pound sledge hammer. The resulting damage was minimal. 2) Three inserts were placed on three different 16.5 inch diameter rotary drill bits, and the bits drilled taconite rock until the entire bit failed. 3) The inserts had somewhat less wear resistance than current art, and exhibited no brittle failures. 4) More work is needed to produce the inserts at near net shape. The test inserts required too much machining.

The project next turned to manufacturing 6.5 inch diameter disc cutters. The cutters will feature a core of tungsten carbide (TC) in a disc body composed of H13 tool steel. The TC inserts are in manufacture and the dies for the disc are being designed.

The plan for next quarter: 1) Investigate materials and manufacturing changes for the fibrous monolith drill bit inserts that will increase their wear life. 2) Begin manufacturing disc cutters.

Fibrous Monolith Tungsten Carbide Insert Testing

Tungsten Carbide Insert Manufacture

During the last reporting period and continuing into this period, five TC inserts were manufactured. The round top inserts were nominally 0.91 inches tall by 0.7 inches in diameter (Figure 1).


Figure 1a


Figure 1b

Figure 1. Two Views of the Round Top Drill Bit Insert. The insert is typical of the cutting tools placed on rotary drill bits. (Orientation of the fibrous monolith was right to left, from the round top to the flat base.)

The insert material was composed of fibrous monolith (Figure 2), where the core fiber material was 96% TC and the boundary material was cobalt. The orientation of the fibrous monolith (FM) in the inserts was top to bottom

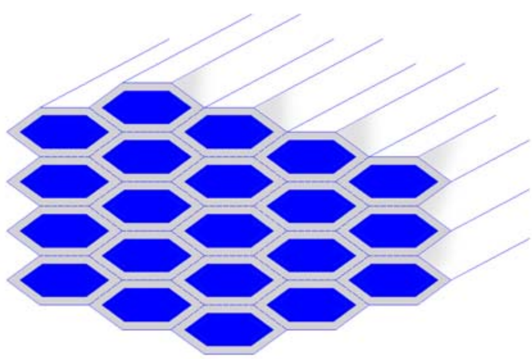

Figure 2. Schematic Drawing of the Core and Boundary Areas in a Fibrous Monolith. The test inserts were composed of a tungsten carbide core (blue, 96 % carbide) and a cobalt boundary (gray, 100% cobalt).

Hammer Test for Drill Bit Inserts

Tungsten carbide (TC) is a brittle material that is susceptible to shattering on impact. To test for threshold brittleness, TC insert manufacturers (e.g. Ingersol Rand) and TC insert users (e.g. the Robbins Company) employ a simple, qualitative, yet effective test: hit the TC insert with a heavy sledge hammer (~16 pounds). An insert that does not survive the impact will be judged overly brittle and suspect for drilling and rock cutting applications. An insert that survives the test will require further testing.

One insert was subjected to several blows with a 16 pound hammer. The insert exhibited minor surface damage at the impact points (Figure 3). The damage appears to be related to the cells in the FM structure. The damage appears as pits that are approximately the same size and pattern as the intact cells.

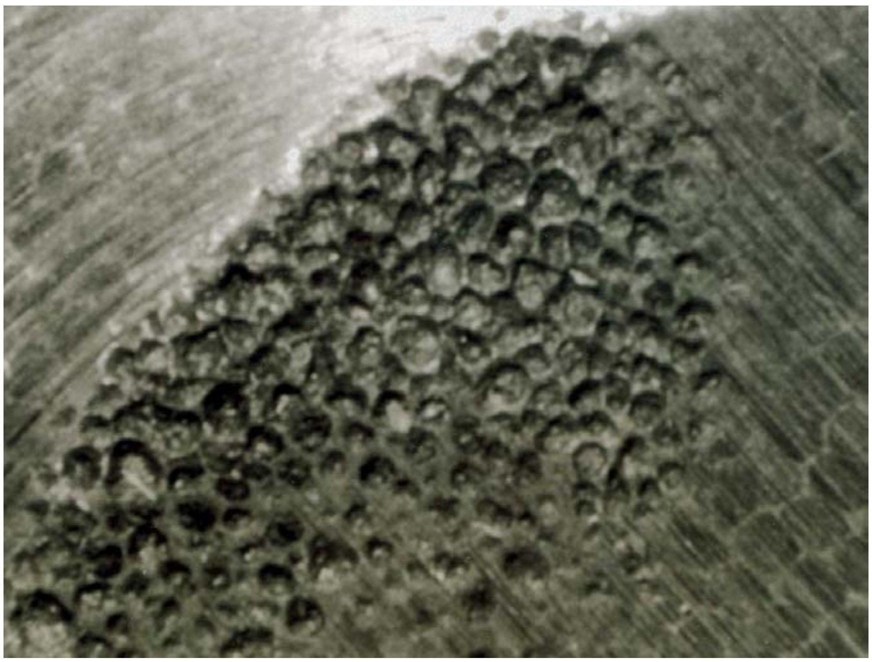

Figure 3. Close-up of the Hammer Induced Damage to the Bottom of the Insert. The damage appears to mostly occur in each fibrous monolith cell. Compare the damaged to the undamaged cells.

Field Testing

Field Test Methodology

Three inserts were placed on three 16 ½ inch diameter rotary tri-cone drill bits (Figure 4). The inserts were on the outermost row of the bit (i.e. the gauge row, also called the heel). The drills drilled taconite rock until the bits were completely worn out. For example, the rotary cone bearing in one bit lost all of the bearing rollers. Additionally, all three drill bits had their heel rows completely worn away, and nothing was left of the inserts, either new or current art on those rows.

Figure 4. Drill Bit Used in Field Tests. The Superior Rock Bit test bit was 16.5 inches in diameter. The "C" carbide was the new art test insert.

Each test bit drilled in excess of 2,000 feet before the bit was discarded. Taconite is a very hard (generally greater than 50 ksi uniaxial compressive strength) and abrasive rock, which presents a challenging environment for drilling.

Field Test Results

The FM carbide-cobalt inserts wore away faster than current art inserts, although the wear rate was not significantly much higher (Figure 5). The relatively soft boundary seems to cause the wear. The boundary layer is composed of cobalt, which is significantly softer than the very hard tungsten carbide core.

It is important to note that there were not brittle failures such a chipping, cracking, and spalling. The FM material exhibited no brittle failure.

Figure 5. Current Art and Fibrous Monolith Inserts on a Worn Superior Rock Bit. The FM insert in the center has worn more than the current art inserts, although no brittle failures have occurred like the small chip on the insert to the left of the test insert.

However, the pitting failures seen in the hammer tests were similar to the appearance of surface of the worn insert on the drill bit (Figure 6). Together, these wear and failure patterns suggest that FM cell boundaries are at least partially involved in the failure and pre-mature wear.

Figure 6. Highly Worn FM Insert on a Worn Superior Rock Bit Drill Bit. Compare the worn insert (center) to the surrounding current art inserts. The two current art inserts at the top exhibit brittle failures. The test insert has similar FM failures as exhibited by the hammer tests in Figure 3.

Disc Cutters

Disc Cutter Design Selection

In addition to work on FM inserts, the research team began work to produce several 6.5 inch disc cutters.

Disc Cutter Manufacture

Design and fabrication of the necessary patterns and molds for the disc was begun. The pattern needed to manufacture disc cutters was machined (Figure 7). The patterns needed to manufacture the tungsten carbide core of the disc were also machined.

Figure 7. Disc Cutter Pattern Used to Manufacture Discs for Field Testing.

Future Work

This quarter was marked by a significant amount of field testing. The results of the field test suggested a change in the materials used in the FM inserts. Instead of a TC core and a cobalt boundary, a TC core and a different mix TC boundary will be manufactured (Figure 2).

The next quarter will be largely dedicated to manufacturing the 6.5 inch diameter disc cutters.