Improvement of Wear Component's Performance by Utilizing Advanced Materials and New Manufacturing Technologies: CastCon Process for Mining Applications

Quarterly Technical Progress Report

for the period starting March 20, 2001, ending June 30, 2001

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July 27, 2001

DE-FC26-01NT41055

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Abstract

A tungsten carbide monolithic preform was produced by Advanced Ceramics. MTU conducted various sintering tests on the preform to determine conditions for removing the organic binder and improving the mechanical properties. The originally selected parameters for sintering did not perform as anticipated and further testing is underway.

Results and Discussion

During this reporting period, Advanced Ceramics Research produced a tungsten carbide (WC) fiber reinforced WC/cobalt monolithic bar using ACR's special organic binder system and extrusion process. This WC fiber reinforced monolithic material was selected as the first choice for making the rock disc cutter and drill bit inserts by the project participants. This bar is about 5" long and 3/4" in diameter. The WC fibers occupying 82.5 vol% of the monolithic are made of fine WC powder, cobalt powder and an organic binder. Each WC fiber in the monolithic is surrounded with a cobalt sheath which is made of cobalt powder and an organic binder. Figure 1 shows a part of the bar. ACR's process can produce the fiber reinforced monolithic structure, but organic binder removal and consolidation are needed to make the monolithic preform strong.

Figure 1. ACR fiber reinforced monolithic bar

Michigan Tech performed several pressureless sintering and pressure assisted sintering (hot pressing) tests on the pieces sliced from the ACR's bar. The purpose is to find the optimum conditions to burn the organic binder and gain excellent mechanical properties of the material. Two sintering tests were conducted in a vacuum furnace. The first sample was heated at a rate of 1°C/minute to 500°C and held for 30 minutes to evaporate the organic binder, then heated continuously to 1100°C and held for one hour. The sample shows bubbles and micro cracks on the surfaces. Figure 2 shows the picture of the sample after sintering. We thought the heating rate might be too quick. The second sample was heated at a

Figure 2. First sintering test.

rate of 0.5°C/minute to 700°C and held for 30 minutes, then heated continuously to 1100°C and held for one hour. This sample also shows bubbles and micro cracks on the surfaces. Figure 3 shows the picture of the sample after sintering.

Figure 3. Second sintering test.

We concluded that pressure assisted sintering is necessary. Two hot pressing tests were conducted in a 20 ton vacuum hot press furnace. The first sample was inserted in a graphite die with bottom and top punches and heated at a rate of 1°C/minute to 500°C and held for 30 minute then heated continuously to 1100°C. 4,000 psi pressure was then applied on the sample by a hydraulic cylinder through the top graphite punch and held at 1100°C for one and a half hour. After cooling and opening, the sample was squeezed out of the graphite die. Figure 4 shows the sample. It seems that the sample was a partial liquid or paste at that temperature. We conducted the second hot pressing test with reduced hot pressing temperature to 950°C. Other conditions were kept the same. The second sample was very similar to the first one. The material was squeezed out of the graphite die. Figure 5 shows the sample. Both shouldn't happen because the melting point of the material should be over 1200°C. We checked the temperature reading of the hot press furnace. The temperatures were correct. We are still working to determine the reason for this problem. One possibility is the high sulfur content in the organic binder which reacted with cobalt, forming low melting sulfide. We will check the theory.

Figure 4. First hot pressing test.

Figure 5. Second hot pressing test.