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 October 1, 2003, ending December 31, 2003

Xiaodi Huang and Richard Gertsch

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Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931

Abstract

In this reporting period, full disc prototype manufacturing tests continued. The disc size and HIP can problems were corrected. Unfortunately, cracking still occurred on insert interface, possibly due to oxidation film on the particle boundaries. This indicates improper off-gassing.

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Executive Summary

In this reporting period, we continued the effort to manufacture a full disc prototype. We increased the thickness of the disc pattern and the resulting discs had the correct dimensions. We carefully welded the HIP cans and performed leak checks before sealing. There were no can-blowing problems encountered in this quarter. We increased the off-gas temperature from 500°C to 1050°C in an effort to eliminate the cracking problem. Unfortunately, cracking still occurred on the H13 body and H13/WC insert interface. Microstructure examination showed an oxidation film existing on H13 particle boundaries. This is an indication of improper off-gassing.

It is planned in the next quarter to check the vacuum system for the off-gassing, increase stem size, use argon for purge and cooling, add a steel mandrel to the sand mold to reduce shrinkage restriction, add a copper coating between H13 and WC insert, and add an oxidation prevention agent in the sand mold.

Experimental

Discs produced last quarter were not thick enough on the disc hub section. Two 1/8" thick steel rings were prepared and bonded on the pattern hub to increase its thickness. We used the modified pattern to make the 6.5" discs this quarter.

The HIPping cans were made of 1/16" thick low carbon steel sheet by cutting, rolling, bending and welding. It required excellent welding to prevent vacuum leaks. Can leaking has happened several times in the past and was a problem in making the discs. In this quarter, we carefully cleaned the welding regions of cans before welding, using sand blasting and wiping with alcohol. We also did a vacuum leak check before final sealing the can.

We increased the off-gassing temperature of the cans from 500°C to 1050°C in this quarter to reduce potential oxidation of H13 powder inside of a can. The off-gassing temperature was high and lasted for 3 hours at temperature. Severe oxidation took place on the can surface and a lot of scale formed. To reduce the risk of leaking due to potential oxidation though the thin steel, we started to look for an oxidation resistant glazing material. We identified a protective coating, named "CeramGuard" for heat treating metal protection. This coating is supplied by A.O. Smith Corporation, Holton Road, Florence, KY 41042, Tel: 606-727-3500. CeramGuard is a group of coatings for heat treating at different temperatures. We selected and ordered CG-27 based on A.O. Smith Corp's recommendation. CG-27 is supposed to be used around 1100°C. We applied this coating to the cans before off-gassing. To further reduce oxidation scaling, fly ash residual carbon was added to the off-gassing furnace to react with oxygen and reduce oxidation of the cans.

Results and Discussions

The cans did not leak during HIPping. This showed that our measures to solve the can vacuum leakage were effective. Figure 1 shows the cans after HIPping.

The discs produced using the modified pattern achieved fairly good near net shapes as seen in Figure 2 and were large enough for machining to final specifications.

Although the off-gassing temperature was increased from 500°C to 1050°C, cracking still can be seen on the disc radial directions (Figures 3 and 4) and contact regions of H13 steel and WC inserts. We assume there are several issues contributing to the problem: 1) powder oxidation, 2) low ductility of H13 material, 3) residual stress caused by the shrinkage restriction of the disc center hole, 4) improper vacuum during off-gassing, 5) too slow cooling after off-gassing to cause re-oxidation, and 6) too little oxidation prevention agent added into the sand mold. A piece of sample was taken out of a disc (Figure 5). The examination under a microscope revealed oxidation films on H13 powder surfaces (Figure 6). Oxidation of H13 powder during off-gassing could be the major reason of cracking.

Conclusions

H13 powder oxidation occurred during off-gassing.

Future Work

We plan to take several measures to overcome the cracking problem, 1) check the vacuum system for off-gassing, 2) use argon to purge the HIPping cans after off-gassing before cooling, 3) quenching the cans to increase the cooling rate and reduce exposure at elevated oxidation temperature ranges, 4) add more oxidation prevention agent into the sand mold, 5) use a metal mandrel to reduce shrinkage restriction of the disc center hole.

References

No references are included in this quarterly report.

Figure 1. Cans after HIPping

Figure 2. 6.5" discs produced, left H13 only and right with WC inserts.

Figure 3. A radical crack in the middle of picture

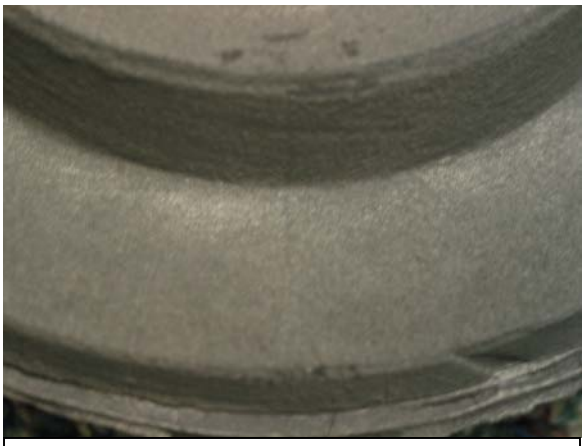

Figure 4. A closer look at the radical crack

Figure 5. A piece knocked off for microstructure examination

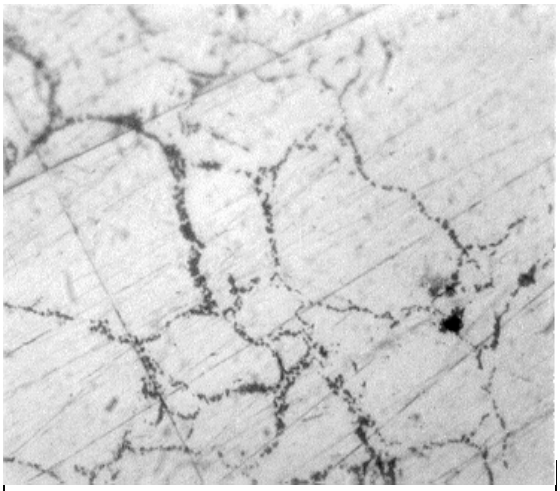

Figure 6. Microstructure examination revealed oxidation films on H13 powder surfaces