Plasma Transferred Arc Welding of Wear Resistant Overlays

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Introduction / Background

Wear of materials is a significant challenge in the oil sands industry. Many iterations of wear resistant materials have been used to combat wear in the severe abrasive environment of the mine. One of the technologies used by Syncrude Canada Ltd. involves the application of wear resistant tungsten carbide/nickel alloy metal matrix composite overlays applied using the plasma transferred arc welding process. Previous work developed optimal powder consumables and welding parameters for PTAW and the unique application. Understanding the interaction between the wear resistant overlays and the abrasive sands is fundamental to improving wear performance and therefore improving component life and overall cost.

Since startup in mid-2000, the wear rates on various pieces of equipment at the Aurora Mine have been noted to be considerably greater than previously experienced at Syncrude's other mine sites. This work attempts to separate the influence of particle shape and size on wear rates, with the intention of using known sand particle characteristics of future mine locations as a predictive tool for wear engineering.

Procedure

To understand how tungsten carbide weld overlays are affected by abrasive oil sand, a series of experiments was designed to evaluate the wear mechanism experienced by the overlays. Four different overlay compositions were tested against four different sand types to determine if the tungsten carbide weld overlays can be optimized according to the size and shape of the sand particles found in the ore.

Welding Procedure

The tungsten carbide overlays were prepared using the *Eutectic + Castolin GAP 3000* AC/DC PTA welding machine. Four welding powders containing macrocrystalline angular WC of various sizes were applied to mild steel base plate using PTAW. The powders were prepared with large carbides (-80/+100 mesh), medium carbides (-100/+140 mesh), small carbides (-140/+270 mesh) and a mixture of all of the above sizes to an overall carbide loading of 65 wt%. The overlays were applied in 300 mm long beads onto 350 mm long plates so that wear coupons in triplicate could be cut from each overlay to confirm the consistency of the deposit. Metallographic light microscopy was performed on each wear coupon to examine the quality of the weld overlay. In general, carbide distribution, carbide degradation and the extent of dilution can assess weld bead quality.

Wear Testing Procedure

A "modified" ASTM G-65 Dry Sand/Rubber Wheel Procedure A abrasion test was conducted on each of the wear coupons. Due to the non-linear wear rate of MMC deposits, the modified procedure consisted of a second 6000 revolution test into the pre-existing Procedure A wear scar. The mass loss after the second 6000 revolution test is used as the benchmark for ranking wear performance. The four overlays were tested against four types of sand: 50/70 standard silica sand, 20/30 standard silica sand, F-95 silica sand and sand from the tailings pond of the Aurora mine in Fort McMurray, Alberta, Canada (consisting primarily of silica sand).

Results and Discussion

Analysis of the wear test results suggests the four sizes of WC particles used in the weld overlays behave differently under varying abrasive environments. Results indicate the medium sized carbides offer the best wear resistance against the coarse 20/30 sand, the fine carbides offer the best wear resistance against the fine F-95 sand, whereas the 50/70 sand showed consistent wear loss independent of the carbide size. The 50/70 sand consistently showed the least mass loss. The F-95 sand was the finest of the four sands yet it showed greater wear than the medium sized 50/70 sand. Therefore, the standard hypothesis that larger sand particles are more aggressive must be modified for MMC wear resistant materials.

Conclusions

From this series of experiments, it can be concluded that the WC particle size used in the MMC weld overlays must be optimized for specific sand sizes. The critical parameter for designing MMC overlays for oilsand service is the mean free path between the WC particles. Mean free path is affected by carbide loading, carbide distribution, and carbide morphology as well as carbide degradation. By optimizing these variablesby altering PTA welding parameters, the ultimate wear resisting material can be designed for the known field conditions. Changes to weld overlay parameters can be made based on known sand characteristics of future mining locations, thus making the technique somewhat predictive.