Metal-Matrix Composites and Thermal Spray Coatings for Earth Moving Machines
Quarter 4 Report

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Abstract:

In the fourth quarter, more pressure casting trials on steel/WC-Co composite were carried out. In addition, initial trials on steel/ Al_2O_3 composite were started. The effects of processing parameters on infiltration process were investigated. It was found the quality of infiltration was determined by wettability of the liquid steel on hard particles, preheating temperature of the die, pouring temperature, and applied pressure. From the preliminary study on pressure casting of steel/ Al_2O_3 composites, little infiltration was observed because of poor wetting and rapid solidification of liquid steel. UC Santa Barbara was able to make a steel/ Al_2O_3 composite in a hot isostatic press which will be used to evaluate the viability of this composite system. For thermal spray coatings, another round of coupons were sprayed for arc-lamp processing trials at Oak Ridge National Lab. Low stress scratching wear measurements at Albany Research Center on coupons from the previous arc-lamp trial demonstrated that the coatings had 3-10X higher abrasive wear resistance than Brinell 500 abrasion resistant plate.

An overview of the progress during the 4th quarter of this project is given below. Research details are provided in the limited rights appendix to this report.

Experimental

Steel Matrix Composites

Based on the results of previous experiments, more pressure casting trials were carried out for steel/WC-Co composites. Several processing parameters were adjusted to improve the quality of the pressure infiltration product. Trials were also performed on infiltration of metal coated alumina preforms.

Thermal Spray Coatings

Another round of coupons were sprayed for high-density, arc-lamp processing trials at Oak Ridge National Lab in early 2002. The materials sprayed and proposed arc-lamp parameters are based on the previous processing trials, as well as wear testing at DOE Albany Research Center. This testing involved low stress scratching wear evaluation of 13 arc-lamp processed coatings, using a dry-sand, rubber-wheel wear test machine.

Results and Discussion

Steel Matrix Composites

Steel/WC-Co composites with limited dissolution of WC-Co particles were obtained when pressure casting parameters were within the right range. The preheating temperature of the die and the pouring temperature have significant effects on the macro- and microstructure of the composite. The applied pressure is beneficial to eliminating the shrinkage cavity and porosity.

For the fabrication of steel/ Al_2O_3 composites, the infiltration was not successful for metal coated alumina preforms. This was due to the poor wetting and the quick solidification of the steel. The metal coating layer on the alumina particles, which was expected to improve wetting behavior, was oxidized instantly when the preforms were transported to the preheated ceramic die. UC

Santa Barbara did have success infiltrating uncoated Al_2O_3 particles using a hot isostatic press, in which the metal and ceramics were heat up concurrently.

Thermal Spray Coatings

Low stress scratching wear evaluation of the arc-lamp processed sprayed coatings revealed abrasive wear resistance gains of 3-10x over Brinell 500 plate.

Conclusions and Future Work

Steel Matrix Composites

Steel matrix composites reinforced with WC-Co particles could be fabricated by applying pressure casting if the processing parameters are optimized and the experimental procedure is well controlled. The fabrication of steel/ Al_2O_3 composite remains a challenge because of the poor wetting and quick solidification of the liquid steel. Further trials will focus on fabricating composites with WC-Co particle preforms and loose alumina particles. Modification of the tooling system will start in the first quarter of 2001. The new tooling system is expected to reduce the manufacture cycle time. UC Santa Barbara will evaluate the steel/ Al_2O_3 composite which they fabricated to identify whether the particle-matrix interfacial strength will be sufficient to withstand the forces of the intended applications.

Thermal Spray Coatings

Another set of coupons have been sprayed for high density arc-lamp processing trials. These trials are planned for early in the first quarter of 2002 and will be subsequently evaluated. Low stress scratching wear evaluation showed that the coatings from the previous arc-lamp processing trials have 3-10x higher wear resistance than Brinell 500 plate. Higher stress gouging wear test results on these same materials are also expected from Albany research early next year.