Metal-Matrix Composites and Thermal Spray Coatings for Earth Moving Machines
Quarter 3 Report

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Abstract:
In the third quarter, progress was made for steel MMCs in the areas of hard particle preform fabrication and in pressure casting, while for thermal spray coatings additional arc-lamp processing trials were executed. For the steel matrix composite effort, a powder metallurgy technique was demonstrated for making hard particle preforms. Initial casting trials were conducted primarily with cemented carbide particles. As with previous efforts to make ferrous matrix cemented carbide composites, particle dissolution during casting will be a challenge which will have to be overcome to reach toughness and performance targets. For thermal spray coatings, lamp processing trials were conducted on number of material systems. In most cases the coatings are being positively modified by lamp processing. In some coating systems metallurgical bonding was created at the coating/substrate interface.

An overview of the progress during the 3rd quarter of this project is given below. Research details are provided in the limited rights appendix to this report.

Experimental

Steel Matrix Composites
In order to selectively place hard particles within a casting and to aid in the handling of the particles, a method must be developed to make preforms of hard particles. Powder metallurgy techniques were employed to create porous preforms which may be infiltrated by molten steel.

Pressure casting trials were started in the third quarter. Initial trials focussed on exploring die wall protection schemes, process flow, and the fabrication of cemented carbide composites.

Thermal Spray Coatings
A number of different material configurations were sprayed onto substrates which will permit abrasive wear testing. These were subsequently processed with the high-density arc-lamp at Oak Ridge National Lab. Besides material, the primary variable explored in this round was the effect of preheat.

Results and Discussion

Steel Matrix Composites
Hard particle preforms were successfully created using a powder metallurgy technique. The continuity of the particle coatings was affected some by the sintering process. Future casting trials, as well as infiltration studies at the Univ. of California at Santa Barbara will help determine the effectiveness of continuous and discontinuous coatings on enhancing infiltration and particle/matrix interfacial characteristics.

Initial casting trials confirmed earlier work on the feasibility of pressure casting steel matrix composites. Cost effective die wall protection schemes were shown to be effective, helping ensure the cost competitiveness of the process. Cemented carbide particles were successfully infiltrated. As has been observed in the past in other research efforts, dissolution of the carbides in molten steel remains a challenge.

Thermal Spray Coatings

Results from the high-density arc-lamp processing trials were mixed. In all cases the structure of the thermal spray coatings were modified, suggesting that the layers were at least partially being melted. For some coating systems a metallurgical bond was created at the interface with the substrate. Some potential elements to encourage interfacial bonding and the development of robust coatings were identified. In previous arc-lamp processing trials the question was raised about whether ceramic grit blasting media used to prepare the substrate surface was impeding the formation of a metallurgical bond. These trials showed that the choice of grit media had no effect on the formation of a metallurgical bond. I

Conclusions and Future Work

Steel Matrix Composites

Hard particle preforms for steel matrix composites may be successfully fabricated using powder metallurgy processing techniques. Initial casting trials continue to support the use of pressure casting as a route to make steel composites. Identification of thin die wall coatings to protect the steel die during pressure casting should aid the economic viability of the process.

Continued work at the Univ. of California at Santa Barbara will provide guidance on selection of optimal particle systems. Casting trials will continue in the 4^{th} quarter with modifications to tooling and casting procedure based on lessons learned from the first round of trials. Procedures will be further modified in an effort to limit cemented carbide dissolution. In addition, pressure casting trials will be performed using alternate hard particle systems.

Thermal Spray Coatings

Arc-lamp processing was found to agglomerate porosity inherent to thermal spray coatings, increase coating hardness, and in some cases, metallurgically bond the coating and substrate. Melting and wetting characteristics of the coatings plays a crucial role in the bonding of coatings and substrates. Fluxing agents may allow for better coating behavior during arc-lamp treatment. It was also shown that grit blasting media composition does not play a critical role in achieving the desired metallurgical bond.

Future experimentation will involve tailoring compositions and material gradients to achieve optimal structures after lamp processing. Guidance on abrasive wear resistance will be provided by wear tests on the coatings to be performed in the 4^{th} quarter.