COMBUSTION CHEMICAL VAPOR DEPOSITED COATINGS FOR THERMAL BARRIER COATING SYSTEMS

1 July 1994 to 15 April 1998
Final Report

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EXECUTIVE SUMMARY

AGTSR FINAL REPORT
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Project Title:
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AGTSR Subcontract No.: 94-01-SR027
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PROJECT RESULTS

Coatings developed

Much of the initial experimental effort was directed at establishing the appropriate process parameters for the combustion chemical vapor deposition (CVD) of the various materials used to modify air plasma sprayed thermal barrier coatings (TBCs). Coating materials investigated were alumina, ceria, magnesium-aluminum spinel, yttria stabilized zirconia (YSZ), and nickel-aluminum spinel. These materials were applied in layers between 0.3 and 3.0 μm thick either directly onto the bond coats of air plasma spray bond coated substrates (interlayers), which were then air plasma spray coated with YSZ, or onto thermal barrier coated substrates (overlayers).

Summary of interlayer coating results (FCT results)

Modified TBCs containing interlayers were furnace cycle tested in air to determine thermal fatigue lifetimes. Some alumina interlayer-modified and some unmodified TBC coated specimens were vacuum annealed in either one or both of two ways. A glass encapsulated vacuum anneal was performed on bond coated or bond coated and combustion CVD coated specimens only. No complete TBCs (bond coat + YSZ) were given encapsulated anneals. Some complete TBC coated specimens were vacuum annealed by General Electric Power Systems (GEPS). This anneal is referred to as a commercial anneal.

Specimens that were given an encapsulated anneal endured the largest number of cycles to failure, whether they contained alumina interlayers or no interlayers, outperforming specimens that were not annealed and those given only the commercial anneal. However, with a single exception, both types of specimens (those given an encapsulated anneal) failed at the substrate/bond coat interface rather than at the bond coat/YSZ interface. Thus, these tests did not measure the extent to which the bond coat/YSZ interface was improved, as the failure occurred elsewhere. This circumstance is believed to be due to the weak bond between the air plasma sprayed bond coat and the substrate.

The commercial anneal applied after the encapsulated anneal resulted in a decreased FCT lifetime for specimens with and without alumina interlayers. The commercial anneal, however, increased the FCT lifetime of alumina interlayer coated specimens that were not given an encapsulated anneal.

Ceria interlayers resulted in a decrease in the number of FCT cycles to failure.

Summary of overlayer coating results (JETS test results)

Combustion CVD-applied overlayers of ceria, YSZ, and magnesium-aluminum spinel were investigated as hot corrosion inhibitors. Thermal barrier coated substrates were mechanically polished and coated with one of each of these materials. These specimens and control specimens were subjected to the jet engine thermal shock (JETS) test using a proprietary composition of calcium-magnesium-alumino-silicate (CMAS) as a corrodant. The percent spallation of each TBC was determined and used as an inverse measure of the efficacy of the combustion CVD layers in preventing hot corrosion damage by the CMAS.

The data indicate that only marginal protection was afforded by the combustion CVD coatings. Analysis of the tested specimens showed that the combustion CVD coatings did not penetrate into the surface porosity of the TBCs. GEPS does not consider the films worthy of further investigation for the purpose of hot corrosion protection.