Impermeable thin Al_2O_3 overlay for TBC protection from sulfate and vanadate attack in gas turbines

Quarterly Progress Report

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ABSTRACT

The project started on September 1, 2001. During last 4 months, one post-doctor has been hired for this project. We have received TBC samples (YSZ/ CoNiCrAlY/ Inconel 601) from Tohoku University, Japan, while processing of the TBC samples was delayed in GE Corp. Research & Development. The TBC preparation in Japan was based on our technical requirement by plasma spray. Bond coat CoNiCrAlY and the YSZ was produced by low-pressure plasma spray and air plasma spray respectively. The morphology of the surface and the microstructure of cross-section of the sample was observed and analyzed by SEM and EDX. XRD was also used to detect the phases in the YSZ. Currently we are processing the overlay Al_2O_3 on the TBC samples by EB-PVD and high velocity oxy-fuel (HVOF) spray techniques in collaboration with Penn. State University and State University of New York at Stony Brook. We will finish comparing the hot corrosion behavior of the Al_2O_3/YSZ/CoNiCrAlY/superalloy system with the YSZ/CoNiCrAlY/superalloy system. The mechanism of hot corrosion will be investigated. The processing-structure-properties relationship of the overlays will be determined.

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1. INTRODUCTION

Current advanced turbine system (ATS) requires thermal barrier coatings (TBCs) on turbine blades and vanes. The TBCs being specified, based on yttria stabilized zirconia (YSZ), have the limited durability for advanced industrial gas turbine applications that have longer durability requirements (30,000 hours versus <10,000 hours), particularly when dirty fuels are burned. Surface deposits (including molten sulfate and vanadate salts) can penetrate into porous TBCs and result in hot corrosion, leading to premature spalling [1-2]. In the present project, it is planed to deposit a dense overlay Al_2O_3 on the surface of the YSZ coating to prevent YSZ coating from hot corrosion by deposits derived from combustion of low-grade fuel and air impurities. The dense overlay Al_2O_3 acts as a barrier to protect TBC and bond coat.

The first stage in this project is the preparation and analysis of the TBC samples. The TBC preparation was based on our technical requirement by plasma spray.

2. EXECUTIVE SUMMARY

We have received TBC samples (YSZ/CoNiCrAlY/Inconel 601) from Japan. Bond coat CoNiCrAlY and the YSZ was produced by low-pressure plasma spray and air plasma spray respectively. The morphology of the surface and the microstructure of cross-section of the sample has been observed and analyzed by mines of SEM and EDX. XRD has also been used to detect the phases in the YSZ. Micro-porous and cracks on the surface and within the as-sprayed TBC were found by SEM. The result demonstrates the importance of depositing a denser overlay coating on the surface of TBC. Currently we are processing the overlay Al_2O_3 on the TBC samples by EB-PVD and HVOF in collaboration with Penn. State University and State University of New York at Stony Brook. By the end of fiscal year (end of August of 2002), the hot corrosion tests in molten sulfate and vanadate salts for the composite Al_2O_3/YSZ coating prepared by the EB-PVD and plasma spray will be completed.

3. EXPERIMENTAL

Flat plates (80mm × 80mm × 3mm) of nickel-based superalloy (6061) were used as substrate. These were initially cleaned, subjected to grit blasting and degreased in ethyl alcohol. An approximately 0.1mm thick bond coat of CoNiCrAlY alloy powder was sprayed onto the freshly prepared substrate by low-pressure plasma spray. The oven-dried powders of zirconia-8%yttira (YSZ) were then sprayed onto the bond-coated substrates to the thickness of about 200-300 *mm* . A Philips PW1700 series diffractometer was employed to perform the phase analysis on the TBC. The morphology of the surface and the microstructure of cross-section of the sample were examined using scanning electron microscopy (SEM) and an energy-dispersive X-ray spectrometer (EDX) equipped in SEM .

3. RESULTS AND DISCUSSION

The X-ray diffraction patterns of as-sprayed TBC specimen shown in Fig.1 demonstrates that it contains predominantly T-phase.

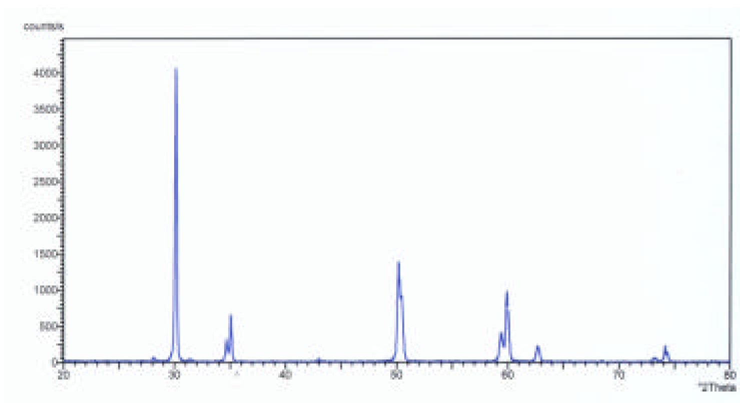

Fig.1 XRD patterns of as-sprayed YSZ TBC

SEM images have provided basic microstructural information. SEM micrographs of the cross-section of as-sprayed TBC, shown in Fig.2, indicated that the TBC had a typical APS microstructure [3], with inter-splat porosity and complex pattern of microcracks.

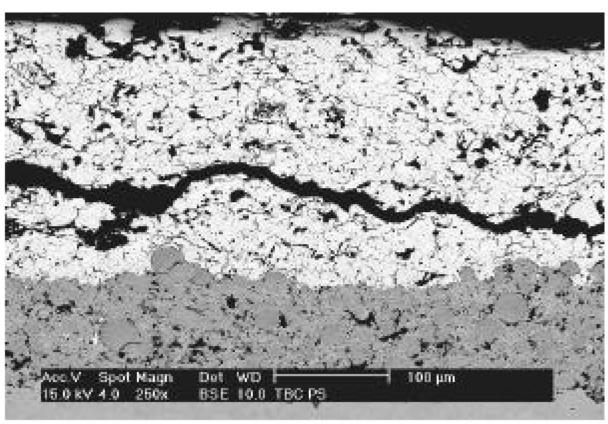

Fig.2 SEM micrographs of the cross-section of as-sprayed TBC

It was found that the thickness of the bond coat and YSZ was 100 *mm* and 250 *mm* , respectively, which are the typical values in applications. Fig.3 shows the surface morphology of as-sprayed TBC. It was visible that there were many microcracks and porous on the surface of the TBC, which are considered to be the path for molten salts to attack the TBC system. Therefore, molten contaminant compositions can infiltrate through the cracks and porous in TBC, causing delamination of thermal barrier coating from substrate. It is desirable to develop a denser and continuous overlay coating on the APS TBCs to prevent the TBC from the hot corrosion attack.

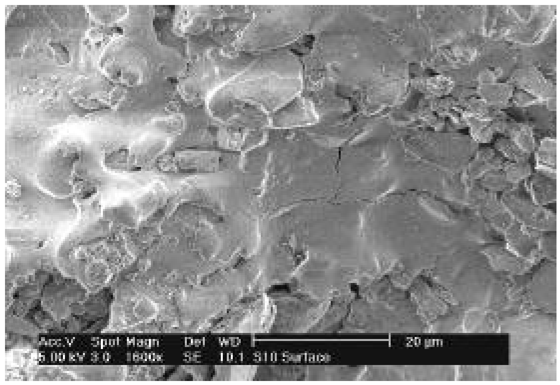

Fig.3 Surface morphology of as-sprayed TBC by SEM

4. PLANS FOR THE NEXT REPORTING PERIOD

Currently we are processing the overlay Al_2O_3 on the TBC samples by EB-PVD and HVOF in collaboration with Penn. State University and State University of New York at Stony Brook. EB-PVD and HVOF are advanced surface coating techniques to produce denser surface layer. The hot corrosion resistance of porous APS YSZ coatings is expected to be remarkably improved by depositing the denser overlay of the alumina coating. Hot corrosion testing under (1) Na_2SO_4, and (2) 95%Na_2SO_4 + 5%V_2O_5, in a furnace with an air atmosphere is being prepared. By the end of fiscal year (end of August of 2002), the hot corrosion tests in molten sulfate and vanadate salts for the composite Al_2O_3/YSZ coating prepared by the EB-PVD and plasma spray will be completed. We will finish comparing the hot corrosion behavior of the Al_2O_3/YSZ/CoNiCrAlY/superalloy system with the YSZ/CoNiCrAlY/superalloy system. The mechanism of hot corrosion will be investigated. The processing-structure-properties relationship of the overlays will be determined.

5. CONCLUSION

By examination with SEM and EDX , it has been found that a micro-porous and cracks on the surface and within the as-sprayed TBC produced by APS. This result demonstrates the importance of depositing a denser overlay coating on the surface of TBC. Therefore, currently we are processing the overlay Al_2O_3 on the TBC samples by EB-PVD and HVOF in collaboration with Penn. State University and State University of New York at Stony Brook. We will compare the hot corrosion behavior of the Al_2O_3/YSZ/CoNiCrAlY/superalloy system with the YSZ/CoNiCrAlY/superalloy system.

6. REFERENCES

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