Gas Turbine Industrial Fellowship Program 2006

Development of APS MCrAlY Dense Bond Coats

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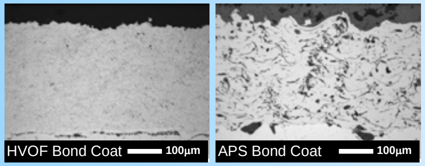
Objectives

To optimize Air Plasma Spray (APS) bond coat microstructure to improve oxidation and spallation life.

Project Intent

Optimization of the spray process and validation.

Want an Air plasma spray (APS) coating to behave as an HVOF (High Velocity Oxy-Fuel) coating.



Background

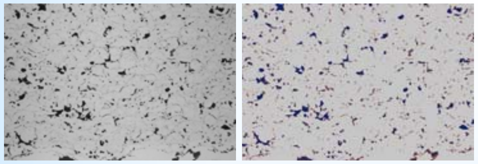
- APS Bond coats suffer from poor microstructures that normally contain high porosity and internal oxidation.
- APS process have the advantage that they permit spraying of bond coats in limited space areas, such as inner diameters of combustion hardware.
  - HVOF process requires relatively long spray distances.

Experimental Setup

- IN718 tabs were sprayed with different spray parameters for analysis.
- Average temperature and velocity data was collected for each spray run using the Sulzer Metco Accuraspray^{TM} system.
- Coating surface analysis was conducted using Confocal Laser Scanning Microscope, and a profilometer.
- All coating cross-section micrographs were collected by optical microscopy .
- A screening experiment was conducted followed by optimization spray runs.

Microstructural analysis

- Carried out using the IQMaterialsTM software package (Evaluation version).
- Analysis consisted of porosity and oxidation area measurements.

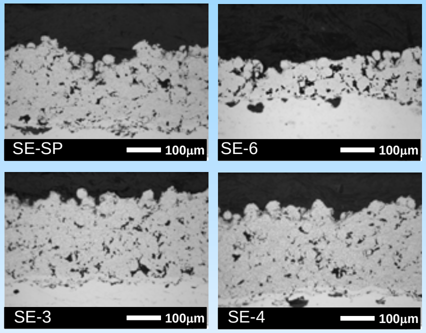


Screening Experiment (SE)

- A starting parameter obtained from the gun manufacturer and sprayed.
- A Design Of Experiment (DOE) was carried out centered on the starting parameter.
- Half-factorial design with a center point (9 spray runs).

Constants	Variables
Primary gas (Ar)	Secondary gas (He)
Gun spray distance	Current
Spray velocity	Powder feed rates
Number of spray passes	

Screening Experiment (SE)

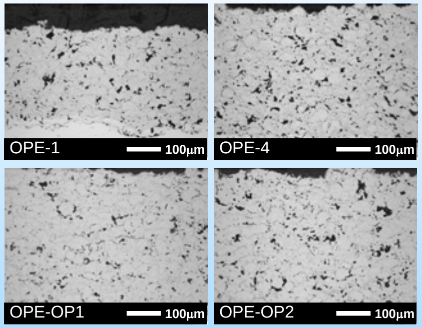


- All coatings developed "cold" microstructures with high levels of porosity and internal oxidation.
- Higher current and powder feed rates produced better coating microstructures.

Optimization Experiment-I (OPE-I)

- Based on the results of the screening experiment, another DOE was carried out to determine and converge onto the optimal spray parameter. Three other parameters were sprayed outside the scope of the DOE.

Constants	Variables
Primary gas (Ar)	Secondary gas (He)
Gun spray distance	Current
Spray velocity	
Number of spray passes	
Powder feed rate	

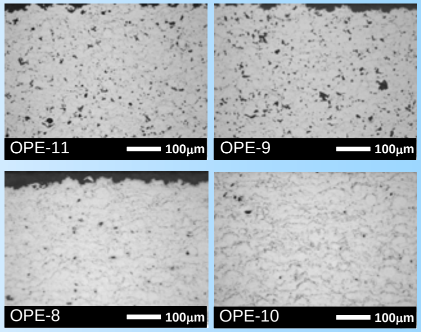


- The coatings developed higher thickness, denser microstructures, and even depositions.
- Porosity and internal oxidation still remained in the coating above the desired target.

Optimization Experiment-II (OPE-II)

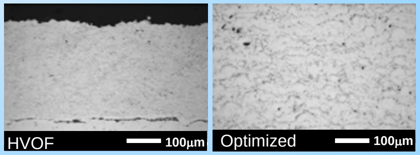
- Powder size was introduced as a variable for these spray runs, using a powder with smaller particle size.
- The manufacturer starting parameter and the higher energy spray runs for OPE-I were sprayed.
- The highest energy spray run produced the Optimal Coating for this study.

Constants	Variables
Primary gas (Ar)	Secondary gas (He)
Gun spray distance	Current
Spray velocity	Powder
Number of spray passes	
Powder feed rate	



- Coating porosity was minimized.
- Deposition efficiency doubled from the manufacturer's starting parameter.
- Surface roughness may be below the desired limit.

Conclusion



- A preliminary optimal spray parameter was achieved for spraying APS bond coats.
- The developed coating microstructure mimics that of typical bond coats sprayed by the HVOF process.