Gas Turbine Industrial Fellowship Program 2005

Thermal Spray Particle Temperature and Velocity Monitoring

University of Central Florida — AMPAC "Bridging the technology gap" — E TMF — GE Energy

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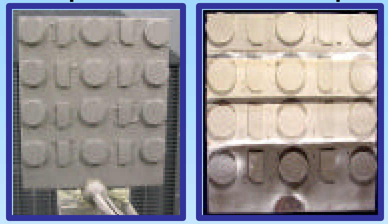
Objectives

To obtain critical average particle temperature and velocity for desired DVC TBC microstructure and tensile adhesion properties.

Background

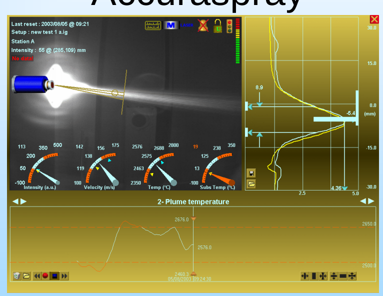
- Plasma spray console allows the operator to control plasma parameters such as the gas flows, current and voltage. These parameters are set at the console. With time and wear of the anode and cathode, the parameters at the console do not necessarily reflect the same conditions at the plasma gun.
- The plume characteristics change with time. Therefore there is a need to understand the effect of the plume temperature and velocity changes on coating microstructure and tensile adhesion properties.
- This study will focus on the effect of varying the average ceramic powder particle temperatures and velocities on coating microstructure and tensile adhesion properties.

Experimental Setup



- Plates were assembled to each hold four experimental runs.
  - Each run included two metallographic and three tensile test samples.
- The plates were first grit blasted and coated with MCrAlY (where M=Ni and Co) bond coat.
- Plates were then masked to isolate each run on the plates.
- YSZ (Ytria-Stabilized-Zirconia) TBC was then deposited by APS for each experimental run.
  - Mean temperature and velocity data was collected using the *Accuraspray*™ *g3* system to determine and specify the TBC deposition conditions for each run.
- The samples were then removed from the plate for tensile and metallographic analysis.
  - Tensile tests were performed to evaluate the adhesion strength of the TBC.
  - Metallographic analysis was performed by optical microscopy to determine coating microstructure.
    - The samples were epoxy mounted, cross-sectioned and polished for analysis.

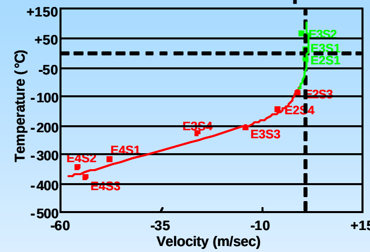
Accuraspray

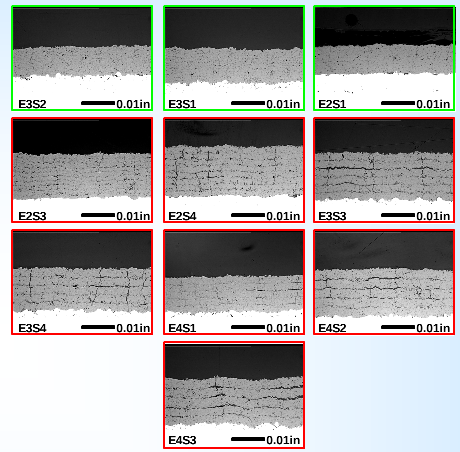


- Calculates average particle temperature and velocity, as well as flow rates, plume vertical position, and plume width.

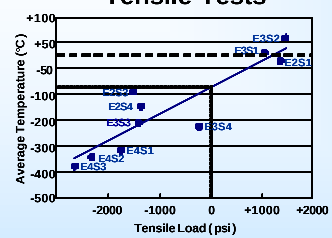
Results

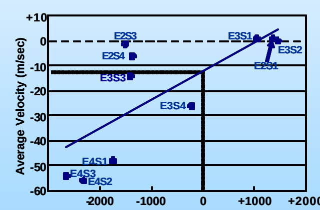
Temperature vs. Velocity Microstructural Development





Tensile Tests





- Tensile testing shows that the adhesion drops bellow desired limits with approximately with temperature drops of 100°C and velocity drops of 10 m/sec.

Discussion

- Variations in powder feed rates had combined effects on both the average temperatures and velocities.
  - The individual effect of temperatures and velocities were not examined due to experimental constraints.
  - Increased feed rates generally resulted in lower average temperatures and velocities.
- TBC microstructures and tensile adhesion properties proved sensitive to decreased average temperatures and velocities.
  - Horizontal cracking developed with lower temperatures and velocities. Cracking originated at the interfaces between spray passes in the microstructure of the TBC's.
    - These may be the result of cold particle deposition, where the particles do not have enough thermal and kinetic energy for proper splat formation.
  - All depositions with low temperature and velocity developed undesired microstructures and had low adhesion properties.

Conclusion

- Plume average reductions in temperature greater than 100°C and velocities greater than 10 m/sec resulted in undesired microstructures and adhesion properties. Plume conditions must be maintained above these limits to obtain the proper DVC TBC's.

Future Work

- Further work must be conducted to confine the operating limits for TBC deposition.
- Temperature and velocity effects must be individually analyzed.
- Variation of other spray parameters that affect temperatures and velocities must be attempted to confirm that particle temperature and velocity control the deposition efficiency.

Acknowledgements

UTSR University Turbine Systems Research — GE Energy