JTTEE5 14:175-176
DOI: 10.1361/10599630524132
1059-9630/$19.00 © ASM International

Meet Our New Colleagues

This column presents selected currently graduating Ph.D. students in the thermal spray field from around the world. Students planning to graduate in the area of thermal spray within next 3 to 6 months are encouraged to submit a short description (1 to 2 pages, preferably as Word document) of the projects they performed during their studies to Jan Ilavsky, JTST associate editor, address: Argonne National Laboratory, 9700 S Cass Ave., Argonne, IL, 60439; e-mail: JTST_Ilavsky@aps.anl.gov. After limited review and corrections and with agreement of the student's thesis advisor, selected submissions will be published in the upcoming issues JTST.

Ti-6Al-4V Alloy by Vacuum Plasma Spraying

Hamid R.S. Jazi, Ph.D. Candidate

Hamid R.S. Jazi

Abstract of Research

In the current study, one of the most important and widely used titanium alloys, Ti-6Al-4V, is chosen to form a near-net-shape structure using the vacuum plasma spray forming (VPSF) process. Since the quality requirements for sprayed structural materials are different than those for coatings, characterization of the standard coating parameters such as porosity, oxide content, and splat morphology does not fully address the microstructure requirements that must be met to ensure optimal properties. As with any structural material, metallurgical considerations such as grain size, phase composition, and phase distribution must be controlled as well. Through the optimization of the structure of the deposit via control of process parameters as well as postdeposition heat treatments, VPSF structures can be made with properties better than conventional cast materials and in some cases equivalent to wrought materials.

The microstructure of the initial powders and the as-deposited VPSF Ti-6Al-4V alloy are characterized comprehensively. The fundamental basis of the relationships between the physical and mechanical properties and the as-sprayed microstructure is elucidated. To provide insight into the deposition and solidification behavior, deposition of a Ti-6Al-4V droplet under vacuum plasma spray conditions on a prior deposit surface is also investigated via numerical simulation and experimental evaluation (Fig. 1). Then, a mechanistic model for the relationship between the elastic modulus and the thermally sprayed microstructure is developed. The mechanistic model is validated by conducting in situ tensile testing using optical microscopy and employing an image based finite-element method (OOF). Then, the effectiveness of postdeposition heat treatments to improve the structure and properties of the as-deposited VPSF material is assessed. Since the microstructure of the VPSF Ti-6Al-4V alloy differs from conventionally processed materials, the response of the sprayed component to heat treatments is different than that for conventionally processed alloy. To study the response of the as-sprayed structure, the mechanisms of grain growth and pore elimination (densification) are investigated in detail. Based on those responses of the as-sprayed structure, three heat treatment cycles are applied to the as-sprayed structure in order to achieve desired physical and mechanical properties of the VPS deposited material.

Key Results

Numerical results showed that about 30% of the droplet material was lost due to splashing starting approximately 0.18 μs after the impact. The thickness of the solidified splat is estimated to be approximately 4 μm in the central region. The average splat cooling rate from the simulation results was estimated to be in order of magnitude 10^8 K/s. Experimental results illustrated splats ranging from 3 to 5 μm in thickness and 100 to 150 μm in diameter, which illustrate good agreement with the numerical results.

The experimental diffraction pattern of the as-sprayed structure yielded a phase composition of approximately 90 wt.% α′ martensite phase and less than 10 wt.% β-Ti phase due to a rapid solidification rate.

Low elongation (~1%) of the as-sprayed structure was due to damage accumulation at the splat boundaries where cohesive failure easily occurs.

The transverse Young's modulus of the as-sprayed structure was found to be proportional to the fraction of the broken lamellae and increased with reduced porosity.

Grain and pore growth in the as-sprayed structure followed a quadratic law during isothermal heat treatments. The rate of grain growth was found to be faster than the pore growth.

Three heat treatment schedules were successfully optimized to achieve three well-known microstructures of Ti-6Al-4V alloy: fine equiaxed α grains, fine acicular α, and bimodal (Fig. 2).

Publications

- H.R. Salimijazi, F. Azarmi, T.W. Coyle, and J. Mostaghimi, 29th International Conference on Advanced Ceramics and Composites, American Ceramic Society, accepted Oct 2004

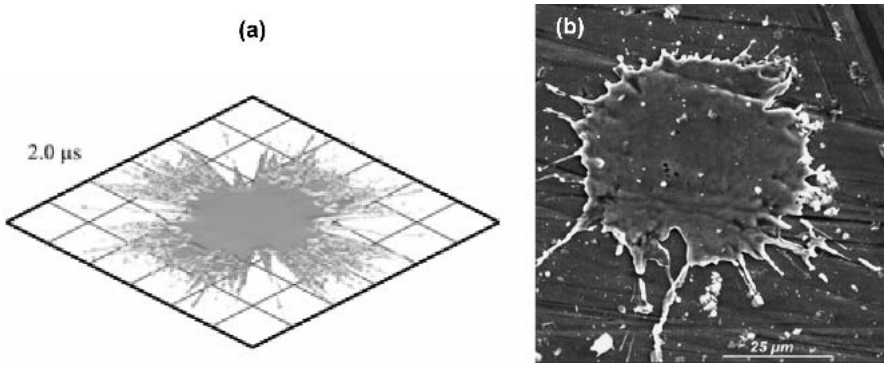

Fig. 1 (a) Numerical simulation and (b) Experimental result of a 50 μm diam Ti-6Al-4V alloy droplet at 1600 °C impacting with a velocity of 500 m/s onto a titanium substrate at 800 °C.

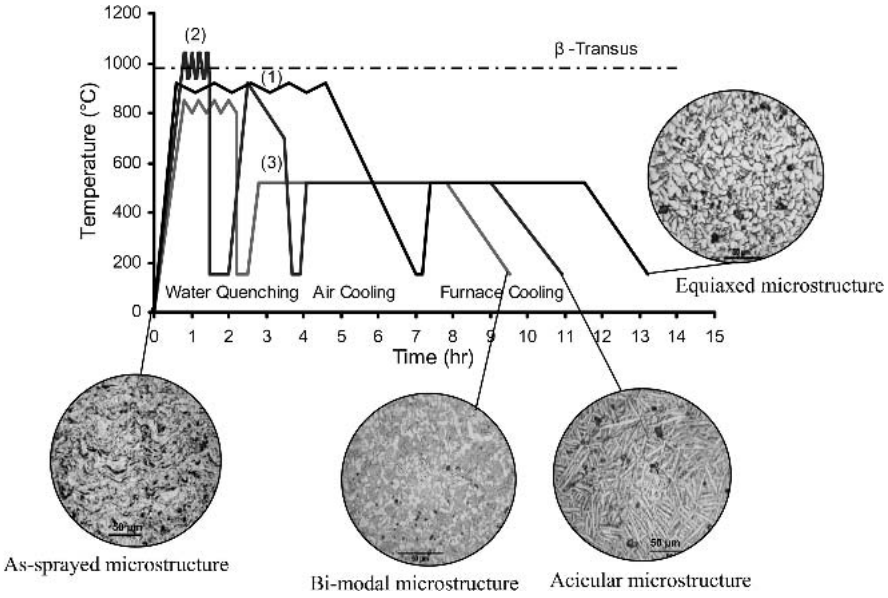

Fig. 2 Recommended heat treatment cycles and the resultant microstructure of VPSF Ti-6Al-4V alloy

- H.R. Salimijazi, T.W. Coyle, and J. Mostaghimi, ITSC 2005, accepted Sept 2004, Basel, Switzerland.
- H.R. Salimijazi, Tenth Meeting of the Thermal Spray Consortium on Coating Formation, University of Toronto, 2004
- H.R. Salimijazi, T.W. Coyle, J. Mostaghimi, and L. Leblanc, *J. Therm. Spray Technol.,* in press, Feb 2004
- H.R. Salimijazi, T.W. Coyle, J. Mostaghimi, and L. Leblanc, *J. Therm. Spray Technology,* in press, Dec 2003
- H.R. Salimijazi, T.W. Coyle, J. Mostaghimi, and L. Leblanc, Thermal Spray 2004: Advancing in Technology and Application (Osaka, Japan), May 2004, ITSC,
- H.R. Salimijazi, T.W. Coyle, J. Mostaghimi, and L. Leblanc, International Symposium on Plasma Chemistry (Taormina, Italy), June 2003, ISPC
- H.R. Salimijazi, T.W. Coyle, J. Mostaghimi, and L. Leblanc, Thermal Spray 2003: Advancing the Science and Applying the Technology, ITSC, May 2003
- L. Leblanc, H.R. Salimijazi, J. Mostaghimi, and T.W. Coyle, Thermal Spray 2003: Advancing the Science and Applying the Technology, ITSC, May 2003
- H.R. Salimijazi and S. Nasrazadani, AESF, SUR/FIN'98, June 1998, (Minneapolis, MN), American Electroplaters and Surface Finishers Society

- **Contact:** Hamid R.S. Jazi, Centre for Advanced Coating Technologies, Department of Mechanical and Industrial Engineering, University of Toronto, e-mail: jazi@mie.utoronto.ca.