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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 the next three to six months are encouraged to submit a short description (one to two pages, preferably as Word document) of the projects they performed during their studies to Jan Ilavsky, JTST Associate Editor, address: Argonne National Laboratory, Advanced Photon Source, 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 of JTST.

An Integrated Approach towards Synthesis and Control of Microstructure and Properties of Thermal Sprayed Materials

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Abstract of Research

In recent decades, sensors have been developed to monitor and control the air plasma spray process to aid in tackling the increasingly challenging coating requirements. Multidisciplinary efforts are underway to understand the process as a whole toward achieving prime reliance. This work focuses on understanding the APS process with the aid of 3-D integrated in-flight and in situ sensors at CTSR toward the design of coatings by tailoring their microstructure and hence the properties. *Process map* methodology has been adopted to provide the scientific framework to understand the relation between the multifarious process variables and the coating structure. This involves identifying the significant variables followed by thorough understanding of each fundamental category of variables that influences microstructure development and their integrated influence on coating microstructure (Fig. 1). Different carefully selected materials are being studied in light of *global process maps* with specific design interest on the different morphologies and size distributions of yttria-stabilized zirconia (YSZ) based thermal barrier coatings (TBCs). Some of the key issues addressed so far are summarized below.

Key Results

Process Reproducibility

Passive method is the traditional way of setting the torch parameters. Active method involves controlling T & V of particles (particle state). Despite the small variability observed in particle state (over few repeated experiments), substantial variability is observed in coating attributes (Fig. 2). Feedback control based active method shows reduced variability in in-flight particle characteristics as well as the coating properties (Ref 1).

Particle Injection

In a systematic study conducted earlier, the particle trajectories were monitored as a function of change in carrier gas. *Optimum* was observed in both particle T & V.

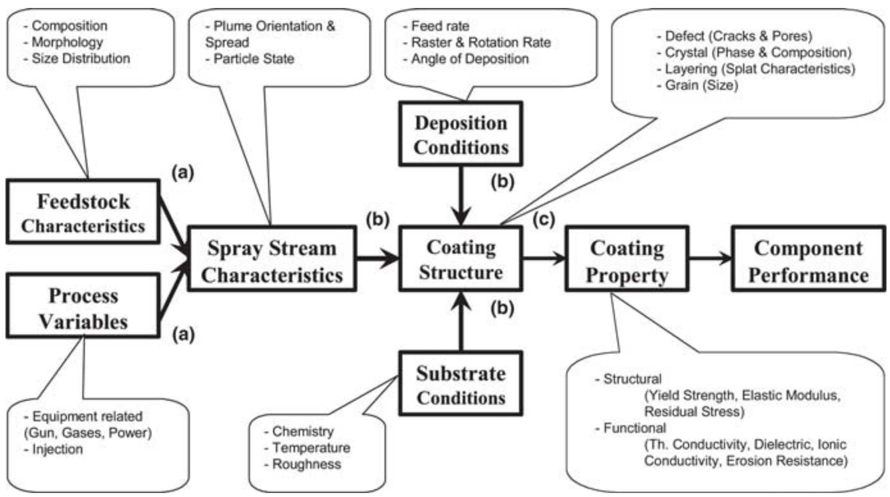

Fig. 1 Some of the most critical variables that influence the APS process as whole have been identified and categorized. *Process maps* or the linkage is indicated by arrows in the figure; (a) is first-order process map, (b) is second-order, and (c) is third-order. It is accepted widely that the coating microstructure influences the coating properties and that in turn influences the component life and performance. The focus of this study (bold in figure) is on controlling this key component, *microstructure,* by understanding the influence of each fundamental block that affect the microstructure and assessing their integrated influence (second-order process maps). It is anticipated that this study would form a basis for building a *design database* or a *thermal spray design handbook.*

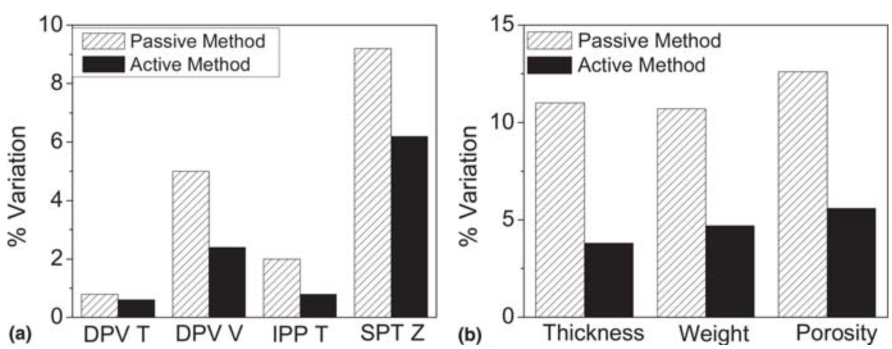

Fig. 2 Comparison of active and passive methods of setting torch parameters on variability of (a) particle in-flight parameters and (b) resulting coatings attributes. The acronyms DPV, IPP, and SPT refer to the different sensors used while T, V, and Z refer to the particle jet temperature, velocity, and position, respectively.

It was also observed that the carrier gas required to achieve the optimum differed for the different total mass flows. But this optimum was achieved always at a certain plume angle (angle between the plume and the spray axis). Thus injection optimization procedure was established (Ref 2).

To assess the role of injection optimization, a set of repeated experiments were done with and without optimized injection (Fig. 3). Optimizing injection resulted in reduced variability in both the particle state as well as coating attributes to a greater extent (Ref 1).

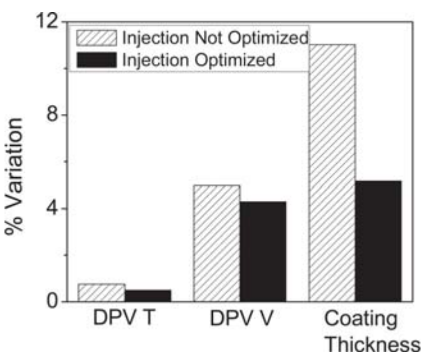

Fig. 3 Influence of powder injection conditions on the observed variability of in-flight particle parameters (temperature- "DPV T" and velocity- "DPV V") and resulting coatings thickness.

Are Averages in T & V Sufficient to Describe the Particle State/Spray Stream?

Figure 4 shows particle temperature distributions from two widely different sets of torch parameters that resulted in very similar average temperatures and velocities (within 20 °C and 4 m/s, respectively). Clearly, the distributions are very different. Microstructure and properties of deposits that were obtained at these conditions also showed significant difference. This suggests that average particle T & V are not sufficient descriptors of the particle state (Ref 3). This calls for a better description of the particle state and of the spray stream as a whole.

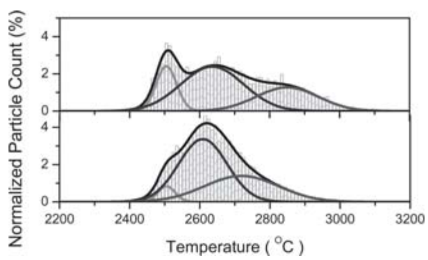

Fig. 4 Particle temperature distributions from two widely different sets of torch parameters that resulted in very similar average temperatures and velocities.

The significance of particle T distribution has also been studied (Ref 4).

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