Thermal Spray Process Training- A New Perspective

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Abstract

Training courses for thermal spray operators have been developed with limited success due to the main emphasis on theory and classroom lecture. As has been observed in Coating Evaluation training like the course taught at IMR in Ithaca, NY, the key to successful training is the hands-on or in this case the actual work with the guns, powder, and control consoles for the thermal spray process being taught. Proper spray methods will be taught in any course. However, students often learn more from "improper" techniques and examples, really understanding concepts such as why the change in a gas flow or powder feed rate ultimately affects the final coating result. The use of plume sensors like the Accuraspray from Tecnar can also be used to significantly illustrate these principles. Students are taught to become "problem solvers", filling their thermal spray "toolbox" with troubleshooting techniques developed by first hearing the theory in the classroom and then having that concept demonstrated in hands-on sessions. Courses are usually one week in length at the company's facility and customized to the vendor needs. Cases studies for both improved production and cost savings will be presented.

Introduction

Traditional courses for thermal spray operators and engineers primarily stress the theory and background of the process in primarily a classroom setting. Courses taught by equipment manufacturers focus on the specific equipment at hand and many times lack the full explanation of how the process works.

The missing ingredient in the training recipe is the lack of adequate hands-on training. What happens when a torn rubber seal is placed in the gun during rebuild? When the powder feed hose has a leak, why will the gun perform incorrectly? Why did the coating lift off with over or under masking? Why did the shadow hard masking required for HVOF allow too much overspray this time as compared to the previous run? Working with actual parts is much different than looking at masking diagrams for parts or drawings that show how to rebuild a gun.

Adequate and comprehensive training is an effective mechanism to prevent mistakes which can result in costly re-work and possible delivery delays that cannot be tolerated. However, there are least three (3) other factors present in industry today that further emphasize the need for a successful employee training program.

<u>Loss of mentoring</u>
With work force downsizing, early retirements, and increased workload on the remaining employees, the time to mentor new employees has all but been eliminated. Trial by fire or on-the-job training (OJT) are the most prevalent modes of operation with little time to learn from experienced co-workers, if any still exist in the company.

<u>Increasing technology/need for computer skills</u>
It is evident that the need for technical expertise in the work force is increasing. The majority of control systems are computer driven and cost pressures result in decreased management or engineering oversight in many cases. Workers must possess problem solving skills and enhanced technical capabilities.

<u>Lack of experienced personnel</u>
With many new technologies and new processes, it can be difficult to find experienced people to fill needed positions. The potential hire's may have some part of the experience necessary in the process technology. However, an adequate training program may be required to provide the missing experience needed to achieve the proper knowledge level.

With less mentors available and the known lack of experienced thermal spray personnel in the market place, the bottom line is: can we afford to employ thermal spray operators and engineers who lack the proper hands-on experience and problem solving skills to meet the current cost and quality conscious mentality? Workplace demands make comprehensive training programs an absolute necessity.

Training Example

A company recently requested a thorough and comprehensive training class on the use of HVOF technologies. Many of the students had plasma experience but had very little knowledge of the new HVOF booth and how the technology differed from plasma. Some of the students had been transferred to HVOF for short periods of time but lack of initial training had prevented them from really understanding the process and the nuances of spraying the parts.

A one (1) week five (5) day program was developed for this company focusing on three major aspects:

- Understanding the "why" of certain steps or tasks in the HVOF process
- Filling the student's "thermal spray toolbox" with useful tools for later problem solving
- Reinforce items 1 and 2 with hands-on examples that illustrate the concepts

Class size was limited to six (6) to eight (8) students to insure adequate hands-on interaction between students and instructors.

The old training mentality (when mentoring and apprentice programs were available) may have been a large class of twenty (20) students for a week long class on theoretical thermal spray techniques yet never touch a console or spray gun. The cost is minimal with 20 students for that one instructor who is a very knowledgeable individual. However, the 20 students miss out on the most valuable lesson of all: pushing the buttons and programming the robot to actually spray the parts and learn both the right-wrong ways to apply the coating.

<u>Why?</u>
There are varied HVOF systems to form the final coating deposit. Why are the systems different from each other as shown in Figure 1 below?

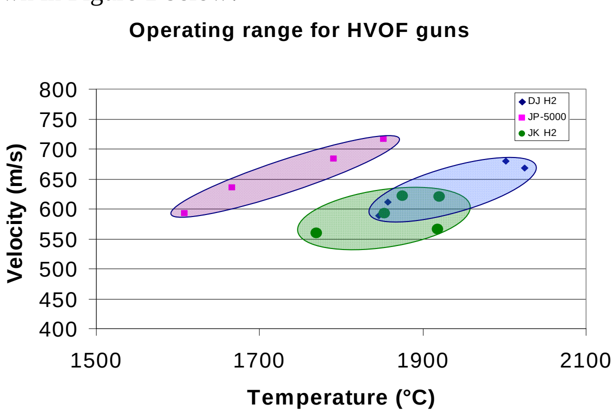

Figure 1: Temperature/Velocity for the Varied HVOF Conditions From the Process Mapping Study (reference4)

Why do the powders from each gun manufacturer have different morphologies, shape and apperance as shown in Figure 2?

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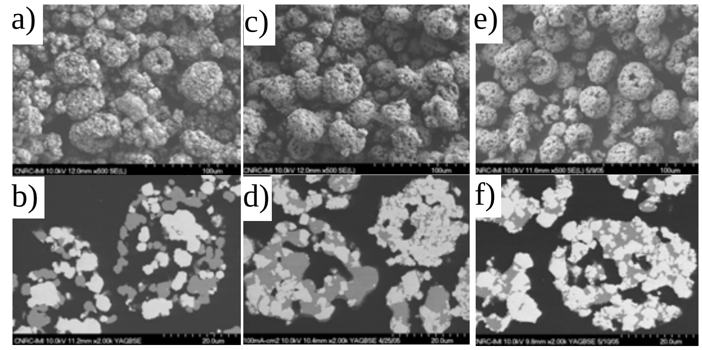
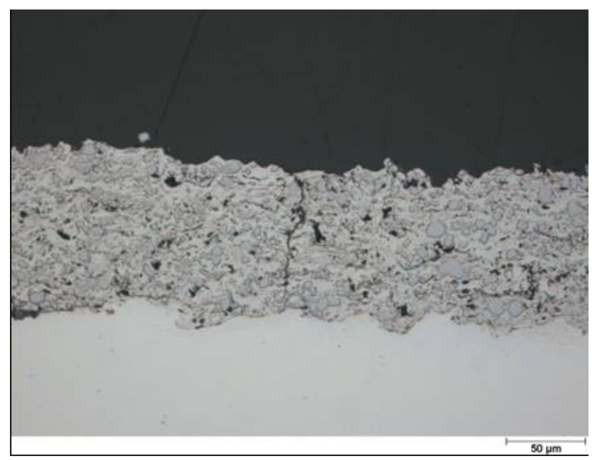
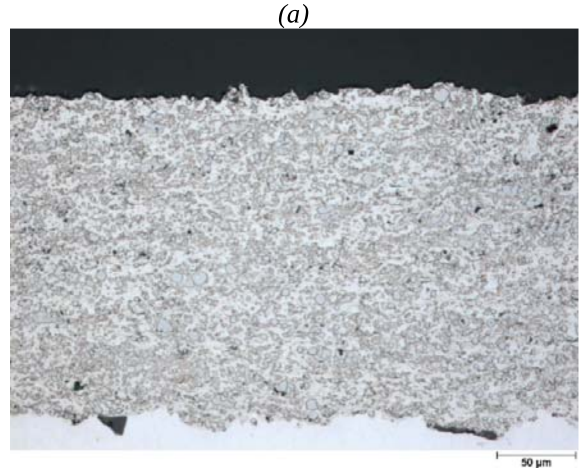


Figure 2: Appearance and cross section of powders a) and b) Diamalloy 2005 NS c) and d) 1343 VM, e) and f) JK-117

Why does the carbide size in Figure 3a (plasma) make a difference when compared to the HVOF illustration in Figure 3b?



(a)

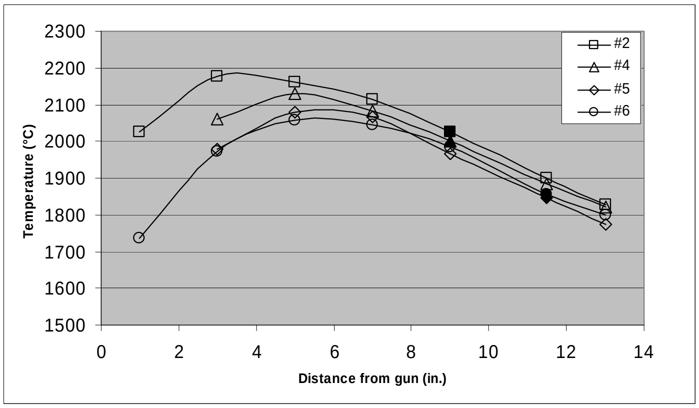


(b)

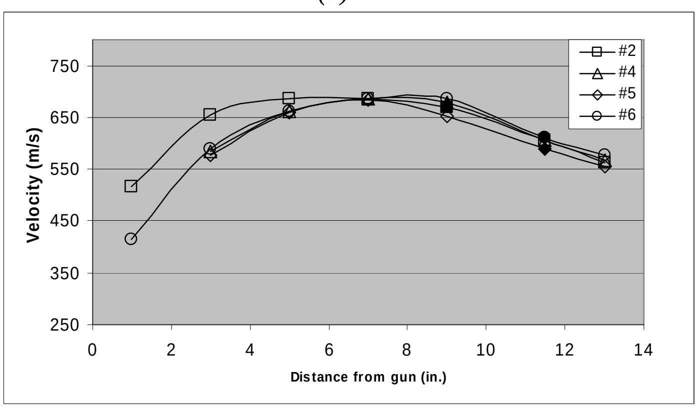
Figure 3: Comparison of Plasma (a) and HVOF (b) Microstructures Regarding the Carbide Content

The Thermal Spray "Toolbox"

In HVOF, very different than plasma, the velocity and temperature vary significantly as the particles travel farther from the barrel or nozzle as shown in Figure 4 below. An operator needs this type of information in their "toolbox" when trying to solve prodcution HVOF problems concerning porosity or residual stress issues.



(a)



(b)

Figure 4: HVOF Temperature and Velocity Profiles Showing How Profiles Vary as Particles Travel Away From Nozzle

Hands-on Examples

Working with the operators in the booth allows reinforcement of principles from the theory portion of the training. In the training, guns and powder hopper were rebuilt by each student. In running the system, the instructors "sabotaged" the guns, powder hoppers, and console making the students troubleshoot the issues to make the hardware operate properly. The use of the Accuraspray Plume Sensor was also an excellent hands-on teaching tool. Table 1 shows the varied examples which were used to illustrate varied parameter changes and the resulting effects on plume output.

Summary

Training is an important factor in the industrial landscape as technologies become increasingly complex and the need for

Table 1: Accurapsray Evaluation in Hands-on Training Class Illustrating How Changing Parameters Affects Outputs as Discussed in the Theory Portion of the Training

		8x	1/500	Coating A					
	Int	*Vel*	*Temp*	*Comments*	*Hy*	*Ox*	*Air*	*FR*	*Carr Gas*
1	54	765	1840	Initial settings	67	33	38	80	28
2	52	777	1875	Rebuild after sabotage	67	33	38	80	28
3	59	777	1870	No substantial change	70	30	38	80	28
4	58	795	1906	More fuel-more energy increasing temp/ speed	72	35	38	80	28
5	55	790	1890	More air that increases oxygen and slight resulting decrease in temp/speed	72	35	40	80	28
6	71	718	1805	Less air that decreases speed keeping particles in plume longer thus increasing intensity	72	35	34	80	28
7	37	813	1920	Decrease in PFR decreases intensity but with less particles available energy can now make particles go faster and get hotter	72	35	38	46	28
8	28	800	1845	Decrease fuel then speed and temp go down	62	35	38	46	28
9	33	785	1900	Decrease oxygen then temp goes up because stoi ratio is better and intensity increases	62	30	38	46	28
10	34	760	1865	Decrease air and velocity-speed goes down	62	30	34	46	28

hands-on training is emphasized. When formulating a training program, a company must assess the needs, define the goals, and develop the necessary system to achieve success: a system which provides opportunity for employees to grow in knowledge that solves both company problems and emphasizes problem-solving capabilities. Hands-on training is the real key to training success. Feedback from classes held recently overwhelmingly highlights the hands-on portion as most beneficial and helpful. While there might be a tendency to virtually eliminate theory training, the balance must be maintained to provide a comprehensive system where students are not just told what to do but learn the ”why” when problems are solved.

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