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Discussion Topics and Threads on Thermal Spray

Compiled and edited by Dr. R.S. Lima, National Research Council of Canada (NRC). These questions and answers were extracted from the discussion group of the Thermal Spray Society of ASM International. The content has been edited for form and content. Note that the comments have not been reviewed. To sign up for the discussion group, visit www.asminternational.org. Go to Affiliate Societies, Thermal Spray Society, *and choose* Technical Resources *for subscribing information. Sign up for e-mail discussion list or simply send e-mail to join-tss@maillists.com.*

Question 1

Stripping procedure for NiCrSiB coatings. Is there an established stripping procedure for NiCrSiB coatings in the unfused state? I am looking for a process that can remove the coatings that have been applied to 174PH, 316, and 4140 substrates.

Answer 1.1: If the coating is not properly bonded to the substrate, just heating again will create cracking and the coating will come out fast. If the coating is bonded then you may have to remelt the powder and then remove it by wire brushing while part is rotating. But note that this is a very messy affair. After this you may have to regrind the part.

Question 2

Hand-held HVOF spraying. Can anyone share their experience and/or recommend an HVOF propylene hand-held system? If possible, please include positives and negatives.

Answer 2.1: Safety first. Hand-held spraying is not recommended for usual litany of issues like quality, repeatability, etc. Besides, who wants to hold a 500,000 Btu device in their hand? An often-ignored problem is noise. Using the latest "recommendations" from OSHA, spray time with hand-held HVOF is severely limited. Here is how the numbers work out. The process produces 125 dBA at the operator's ear, hand-held. The best earplugs have an NRR (noise reduction rating) of 33 dB, while the best earmuffs have an NRR of 29 dB (these are laboratory numbers.). Adding the two together you get roughly 32 dBA. After all, it is logarithmic. OSHA and NIOSH have different views on how hearing protection is derated in the field. Since OSHA can fine you and NIOSH does not, we will worry about OSHA for the moment. OSHA derating of the laboratory values for NRR's follows this formula: 125 dBA TWA – (32-7)/2 = 113 = 20 min exposure according to OSHA's publications; where 125 dBA is the noise level of conventional HVOF processes (kerosene fueled devices produce noise levels of 133 dBA); 32 is the combined NRR of muffs and plugs; and 7 is the reduction from the conversion of laboratory data (dBC to dBA). The division by "2" is from OSHA's CPL 2-2.35 A, which is somewhat consistent with NIOSH at that point.

Question 3

A coating to withstand pressure and corrosion. I am using a valve made up of 4340 high-strength steel. It works in an environment with a pressure of 3000 bar and a temperature of 350 °C. We are using SUS 630 as a coating material. SUS 630 withstands the corrosive environment but it does withstand such high pressure. Does any one know a coating material that can withstand such pressure and corrosion?

Answer 3.1: We have chromium diffusion coated valve stems and bushings of 4340 in similar applications, reheat treated to original hardness and polished. The iron-chromium alloy substantially improves corrosion and lowers friction by formation of chrome oxide and since it is metallurgically bonded will not chip or flake under pressure.

Answer 3.2: A Teflon coating may be the solution.

Question 4

Respraying a coated piece. I have sprayed a part with low-carbon steel (arc spray) and was 0.020 in. above finished size when I experienced equipment problems. I will not be able to resume spraying for a few days. Is there a safe procedure to continue without having to machine the coating off of the part and start over? It is a large part, and I would like to avoid starting from scratch.

Answer 4.1: I have observed that it is not necessary to start from scratch in case of arc sprayed coating if work is stopped due to any reason. You just have to protect the surface against oil contamination. You can protect the top surface using clean paper.

Answer 4.2: Keep the surface dry. Before spraying, I would preheat the surface to temperature usually reached during "non-stop" spraying. In arc process bonding increases with lowering the atomizing air pressure, i.e., not increasing it. You may also increase amperage. The target is to atomize wire to larger size particles, also more overheated.

Answer 4.3: Another successful technique is to lightly grit blast (e.g., 50 psi air pressure) the deposit surface using hardened cast steel or iron grit (not shot), ~G16 in size, ferrous grit for a ferrous coating like yours. This will remove any oxide. Start blasting from about 12-16 in. The other suggestions given by the other members should also be followed. I tend to agree that when respraying, start using "bond parameters." This generally means using a low air pressure initially.

Question 5

Standards for fire protection. I am looking for practices, standards, or codes in fire protection methods for an automated thermal spray system.

Answer 5.1: Try the TSSEA Web site. You can download the code of practice for the safe installation, operation and maintenance of thermal spray equipment: www.tssea.co.uk.

Answer 5.2: The expert in this field is the National Fire Protection Association (NFPA). You can find their Web site at www.nfpa.org.

Question 6

High-emissivity coating. Does anyone know of good high-emissivity coating materials (>0.85) with stable emissivity values over a large temperature range that do not require a heat treatment after thermal spraying?

Answer 6.1: Take a look at the following reference: Y.S. Touloukian, D.P. DeWitt, and R.S. Hernicz, Thermal Radiative Properties (Coatings), *Thermophysical Properties of Matter,* Vol 9, IFI/Plenum, New York, 1972, p 980-981. According to this reference the emissivity of an air plasma spray titania coating, from 450-1300 K was almost constant at 0.85. I measured the emissivity of an HVOF-sprayed titania at room temperature: 0.87.

Question 7

Almen strip test. Does anyone know about better configuration for Almen Test (residual stress measurement) applied for HVOF coatings? We have already tried to use Almen strips of SAE 1070 cold rolled spring steel, but results suggest that strip deformation was affected by temperature of process (~250 °C).

Answer 7.1: Do a "dummy run" on an Almen strip under the same conditions as you would spray but with no powder feed, and measure the change in arc height due to just the "thermal effects."

Answer 7.2: You asked for a reference to help you: J.P. Sauer and P. Sahoo, HVOF Process Control Using Almen and Temperature Measurement, *Thermal Spray 2001: New Surface for a New Millennium,* C.C. Berndt, K.A. Khor, and E.F. Lugscheider, Ed., ASM International, 2001, p 791-796.

Answer 7.3: I have had both good and bad luck using Almen Strips to compare coating stresses in spray processes. I have not seen changes in deflection by dry running the torch over the strips with no powder as some suggest doing in the literature. Perhaps there is a change in some very high heat input short standoff processes, but not in any that I have tested. What I have seen are problems with differential thermal expansion, thermal gradient problems, and thickness control issues. Depending on what your goal is, these may all be valid contributions to what you really want to measure. If you are concerned about the part-coating interaction and the system results, try duplicating your part material, thickness, manipulation, etc. Be careful about reducing the size of your traverse pattern to get results quickly, as this will affect all the thermal conditions. It is okay to do as long as you can quantify and correct for that influence over the range of parameters that you are running. There is also a nonlinear thickness influence. This is due to both nonequilibrium temperatures and gradients and the laminated beam effects. You may be able to reduce or eliminate the thermal influences by careful time, temperature, and manipulation control. A curve can also be fit to some data to get the formula for correcting deflection for coating thickness (when varying parameters it is difficult to get a well controlled test with consistent coating thickness). As to using the material properties and the beam equations to make the thickness corrections, the exact coating properties are rarely known well enough, so the empirical method is usually the simplest.

Question 8

Etching alumina. Can anyone tell me how to etch a cross section of Al_2O_3 to reveal grain boundaries? Could HF work? If so, in what concentration?

Answer 8.1: I used 3% HF + distilled water to etch alumina. I did find variations in grain coloration due to different attack rates for alpha alumina and gamma alumina. Be careful, porous alumina will leak out HF, so use a two-step ultrasonic cleaner or you will etch the optics of your microscope.

Answer 8.2: Yes. 10% HF should be sufficient.

Question 9

Coating application in a pipeline. Have any of you tried thermal spray applications on any pipeline system? I am searching for three things:

- Viable thermal spray application process for underground pipeline systems that are exposed in harsh environment. I heard that Sulzer Metco has a portable wire combustion system (Roadrunner 14EH mobile), that might be good for field application. Any other suggestion on this?
- Coating materials. Currently I am thinking of testing zinc, aluminum, or zinc/aluminum alloys. I believe that someone in this community might have done some work in above ground application (such as bridges or etc).
- Economics. Knowing the fact that coating large section of pipeline is challenging due to the coating material/system cost and a labor charge.

Answer 9.1: Sulzer Metco has made a Rota-DJ system for spraying stub shafts on large landing gear that works quite well. A similar technology could be used for a continuously rotating, motor-driven "pig" to travel through the pipe and coat it as it travels. Wire-feed system may be a problem depending on the inner diameter of the pipe to be coated, as well as, the creativity of the engineers on the project. For atmospheric corrosion, the aluminum-zinc wire is excellent, but I am not sure what type of corrosion you are trying to stop; other wires and/or powders may be a better choice. I think the Roadrunner has been discontinued.

Answer 9.2: For your question No. 3, I have personally done ground chimneys up to 72 ft in situ positions successfully with pure 99.5% Al. Other applications exposed to marine corrosion have been done successfully.

Question 10

Coatings for caustic environment. A caustic environment in flue gas desulfurization (FGD) system at power plant requires a material with high sulfur resistance. Currently, power plant applies Teflon as protective film on C276 cladding or SUS 316L substrate. Have you experienced or tried to perform thermal spray coating for sulfur resistance in FGD system?

Answer 10.1: Nickel-Chrome, with chrome greater than 40%, is very resistant to sulfur at high temperatures. Some of the powder vendors make a 50-50 NiCr powder that should do well. I assume we are dealing with some liquid attack here, so I would recommend HVOF, if possible, to get a dense coating to provide a barrier to the substrate. Coating thickness perhaps 0.50 mm. If the corrosive medium is purely gaseous, you might consider arc spray for ease of application and more favorable economics. There is a Ni-43Cr wire available that offers similar resistance as the powder. However, I worry that the porosity of arc spray coatings may cause delamination if liquid is present during shut down. If you do try arc spray, I would suggest thicker coatings, 0.50-0.75 mm. Both coatings have a good track record protecting tubes and other components in coal fired boilers that are high in sulfur and also in black liquor recovery boilers in the paper industry.