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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 e-mail 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. It is important to point out that the e-mail discussion group was relaunched on August 29, 2007. To sign up to the e-mail discussion group previous and new subscribers to follow the instructions listed below:

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Question 1

Effect of microstructural preparation on porosity measurements. Can people in the community comment if they have observed differences, such as porosity content (i.e., in TBCs) or metal content (i.e., in Al/polyester abradables), in coating microstructures when samples are mounted?

(a) Parallel to the direction of spray passes

(b) Perpendicular to the direction of (cross section to) spray passes

Answer 1.1: I have not observed differences in apparent percent of porosity or phases, but certainly in appearance of the microstructure, particularly when spray angles are not perpendicular to the substrate and when problems with cluster oxides/porosity exist. We need to remember coating is a three-dimensional object viewed in two dimensions.

Answer 1.2: We have found no microstructural differences in orientation of the sample, but cold mounting *versus* hot mounting can produce effects on coating porosity.

Question 2

Oxidation of powder and wire during storage. Is anyone aware of any studies done for any oxidation or other concerns for powder and wire storage over periods of time? Secondly, besides the usual vibrating/sieving and storing in a specified heat condition along with vacuum packaging on an opened bottle, is anyone aware of other techniques?

Answer 2.1: I have also noticed that Cu-based wires like aluminum-bronze tend to age-harden over periods of time and create problem while spraying.

Answer 2.2: Interesting observation! What you are stating is that Cu-based alloys may have a shelf life. Just wondering if anyone else is aware of this issue.

Answer 2.3: During my previous job, we did find a couple of bottles of Cu powder that had been on the shelf for about four years. Visual examination showed the surface of the powder was oxidized, but we could not detect any change in spraying or macrohardness. I am sure these materials have a shelf life, but storage conditions and powder chemistry would make it unique to each other.

Answer 2.4: Your observation is absolutely true as powder becomes soft once it passes through the flame. However, aluminum-bronze wire creates problem when age-hardened while feeding through arc-spray torches. If I find problem with a wire, I respool it on the steel spool and heat it in the furnace up to red hot and allow it to air cool. The top layer becomes oxidized, but I am able to spray wire and get the same properties of previous sprayed coatings.

Question 3

Emerging applications of thermal spray technology. I wonder if subscribers would care to comment on the emerging application areas and segments for thermal spray.

Answer 3.1: A few very quick comments from an industrial manufacturing perspective. Without new breakthroughs and inventions in the TS equipment and methods, there will be no new application areas because the competing (non-TS surface coating) technologies are, also, making incremental improvements. So what limits TS today?

- Feed material utilization—the deposition efficiency should be above 95%, across the board, rather than the present 50s-60s. Droplets or powders need to stick better and minimize an excessive off-spray characterizing all present technologies. Can anyone combine HVOF with rail-gun or APS/VPS with the electrospray methods used in spectroscopy and medical fields? The lack of consensus concerning factors controlling droplet/particle adhesion is just amazing—some advise the highest drop/substrate temperatures, the others the highest speeds/quench rates; little is really done to bridge and reconcile the new cold-spray learning with the traditional TS approaches. What follows are somewhat "territorial" questions we hear about laser powder cladding—is it already a thermal spraying or, maybe, still a welding technology? Clearly, there is a need for R&D and a broader view here.
- Heat management—how much thermal or kinetic (or combined) energy do we really need to consolidate a coating on substrate surface? How many substrate materials can take this huge amount of thermomechanical energy we are using during thermal spraying? Are there any other approaches to adhesion and bonding? Metallic/polymer composite solutions? Self-propagating synthesis reactions and materials converting interface? Clearly, there is a need for R&D here.

- Poor coating resolution (unless you sell the masking stuff and powders) and difficulty to coat higher-value, precise components including those with ID surfaces and holes. Spraying more and more (5, 10, 25, even 80+) lbs/h of metal was considered to be an achievement, but you cannot make really good profit spraying boiler walls or rusting bridges. The thermal spray and, yes, the cold spray coating industry should start diversifying its product lines into (a) heavy units (for waterwalls and such), and (b) small, highly specialized, ‘‘desktop’’ units for coating hip or dental implants. The days of ‘‘hand-held torch fits all’’ are over, at least as far as the new application areas are concerned.

Answer 3.2: In the consulting side of business, we are seeing trends in the following areas of national priority (energy, etc.), trends following ‘‘growing’’ business areas (aerospace, oil & gas, electronics, etc.), as well as newer technology areas that private equity, corporations, and other investors are investigating to be first to market.

Just as a few brief examples—On the west coast, we continue to see semiconductor (protective coatings) and electronics grow, with many companies that are newer to thermal spray industry and getting more involved.

In the aerospace industry, HCAT (landing gear and actuators) applications continue to grow and are spreading to other products. Also interesting is that as more composites are being implemented in commercial aero, potential applications for metalized coatings are being investigated to address some items here.

In areas of national interest (energy and others), more work is going into areas such as coatings for energy production and cost reduction applications—oil & gas (upstream and downstream), oil sands, and so on.

Nano continues to draw interest from both large corporations and smaller start-ups backed with investor capital to be first to market in this area for a host of coating purposes. I think the TSS e-mail list last week advertising for a thermal sprayer for nanocoatings was interesting and may reflect what I am seeing in nanoconsulting work—continued investment and interest.

Question 4

Leakage in titanium tube plates. My client has a steam power plant and a condenser with titanium tubes. The problem is leakage in their tube plate (about 3 m × 4 m) where the tube is welded. The material of the plate is titanium of 0.36 mm thickness and backed up (behind the tube plate) by a 28 mm titanium plate as well (i.e., double plates). Nowadays, the tube plate leaks and downs the efficiency to about 50%. Please let me know if you have any experiences to build up the surface of the plate. They do not want to grit blast it due to the fact that the titanium thickness is very thin.

Answer 4.1: This looks rather challenging for thermal spray. If you are looking to build up the material by spraying titanium, then in order to avoid oxidation (and titanium oxidizes very readily) you would be looking at either VPS or an effective inert-gas-shrouded air plasma or twin-wire arc-spray. The inability to grit blast the surface prior to spraying also presents concerns. If it cannot be grit-blasted, then can it be chemically ‘‘etched’’ to provide a metallurgically clean and active surface?

Answer 4.2: You might want to consider cold spraying of titanium instead of going for a vacuum or inert environment. That would help address the concerns about oxidation. Cold spraying is somewhat more tolerant regarding surface preparation issues, though the surface would still need to be prepped in some manner to assure that it is clean and contaminant free. Cold spray would provide a dense, reasonably strong, though possibly somewhat brittle coating in the as-deposited state. It could also build up a relatively thick deposit quickly with a compressive residual stress state.

Question 5

Removing HVOF-sprayed WC-based coatings. We have a component coated with HVOF and is WC-based, and part of the coating has worn off exposing the base material, which also has been substantially worn off. Now we want to rebuild the base material by welding and subsequently coat it with HVOF. How do we remove existing coating, perform weld buildup, and recoat the part using HVOF?

Answer 5.1: High-pressure water jet removal is one option.

Answer 5.2: In general, it is always best to remove all previous coatings to ensure adequate adhesion of the new material. The component has been in service, so the remaining coating may be contaminated or changed by service conditions. A WC coating can be removed by grinding with a SiC or diamond wheel or possibly (knowing base metal) chemically stripped.

Answer 5.3: Yes, you can blast the old coating off, perform weld buildup, and reapply HVOF coating. The weld integrity will need to be high quality, so that some additional grit blasting can be performed on the new weld surface just prior to HVOF application. Bond integrity at the coating over lap area always presents possible problems. I would choose a grit size that provides ‘‘good’’ surface roughness on the weld area and also lightly roughens the previous HVOF coating without degradation. A grit recommendation for this would be difficult due to differences in equipment and hose size/lengths. The new coating should be tapered ‘‘fade out’’ onto the old coating surface.

Answer 5.4: From previous experience, we have better success removing HVOF-sprayed coatings with aluminum oxide (coarse grain) grit, and depending on grain sizes you can still achieve a coarse surface.

Answer 5.5: I recommend water-jet abrasive blasting as was suggested earlier for removal of HVOF-sprayed coating. To prepare welded surface for subsequent HVOF overlay, grit blast should be employed with stainless steel-hardened grit. Standard steel grit is not recommended on stainless base metal with the potential of galvanic corrosion. Alumina with correct grit size can work as well, but will break down quickly requiring fresh grit to be added at regular intervals. The oxide can break down to dust. It should be blown off or an organic (nontoxic) wash used just prior to spraying.

Question 6

Standards on arc-spray related to corrosion. My company is going to employ arc-spray to repair corrosion damage in pipes. To develop our technical specification about this work for our customer, we need some information about specifications and standards about arc-spray. I have found some information in TSS website but I would be grateful if somebody could help us with more extended information.

Answer 6.1: A good place to start would be to look at a few of the standards put out by the U.S. Navy. Some of these may be geared toward flame spraying than arc-spraying, but the principle should apply. The standard numbers I show may be updated with more recent revisions, but it can get you started.

(1) MIL-STD-1687A (SH)—Thermal Spray Processes for Naval Ship Machinery Applications

(2) MIL-W-6712C—Military Specification—Wire: Metalizing

(3) MIL-M-80226B—Military Specification—Metalizing System, Electric Arc

(4) DOD-STD-2138(SH)—Metal Sprayed Coating Systems for Corrosion Protection Aboard Naval Ships

(5) ANS/AWS C2.18-93—Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites