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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 to the discussion group, visit www.asm-international.org. Go to Affiliate Societies, Thermal Spray Society, and under Technical resources sign up for e-mail discussion list—or simply send e-mail to join-tss@maillists.com.

Question 1

Arc spraying stainless steel on aluminum. I am considering arc spraying 316 stainless steel onto aluminum. The application is decorative and is to be applied to the interior hull of a large boat/small ship. The customer desires a pewter-like finish. The coating will remain as-sprayed. It will be subject to some saltwater exposure. Is this a viable application? If not, what other materials would qualify? The coating will possibly be sealed or clear-coated.

Answer 1.1: Stainless steel is not good for exposure to seawater application due to chloride content, which can cause corrosion. Monel/Cu-Ni alloys are best suited.

Answer 1.2: Why not consider arc sprayed tin alloy? To prevent galvanic corrosion ensure that you do seal the arc sprayed coating.

Answer 1.3: I think this is not a good application. The anode (the boat) will corrode at a faster rate with any tiny pore allowing the seawater (electrolyte) to go through. Even sealed, this is a dangerous coating/substrate combination. How about a material more anodic than aluminum instead of SS 316?

Answer 1.4: The problem is galvanic corrosion caused by any coating more noble than the aluminum substrate. Almost every metallic coating will be more noble than the substrate and will enhance corrosion. I assume that the aluminum is actually an alloy of aluminum and will be (slightly) more noble than only a few other metals. Have you considered using pure aluminum in an arc wire spray? At the right spray distance, the surface texture and color will be similar to pewter. You may consider aluminum-magnesium. Basically, you need to obtain a comprehensive copy of the galvanic series. Any suitable metal you use will have to be less noble than your aluminum hull.

Question 2

Nondestructive test (NDT) on babbitt. I would appreciate your help on proper NDT method after we use arc wire thermal spray with babbitt material on old casting babbitt of gland seal journal bearing. We tried to apply ultrasonic testing (UT) and found some signal that might be lamination, but I am not sure about signal that appeared on UT display.

Answer 2.1: It is very difficult to carry out NDT such as ultrasonic test on sprayed babbitt coatings. I have encountered this problem many times in convincing customer about good bond. In one instance, the bearing was rejected as it was showing delamination; however, after removal we noticed that it was a perfect bond. The results of the test are very confusing. Right now we clearly specify that we will not carry out any NDT on sprayed bearings. Up to this point we have sprayed many bearings and they are working fine.

Answer 2.2: Try eddy-current testing.

Question 3

Corrosion in stainless steel. I am spraying a nonskid coating onto walkways for a food plant. I have tried 316 stainless steel arc sprayed onto 304 stainless, and it is rusting even after sitting only out in the rain. The base material is all 304 stainless steel. Any suggestions for a material that can be arc sprayed and not show any signs of corrosion even after wash down with cleaning chemicals for a food plant?

Answer 3.1: You lost too much chromium with the stainless during spraying. You should try NiCr 80/20 wired arc sprayed.

Answer 3.2: Will aluminum work for you? It is the best choice for antiskid when exposed to the elements. It has a good track record on navy ships.

Answer 3.3: The best I have seen is DURALCAN arc sprayed wire, or straight aluminum arc sprayed wire as second choice.

Answer 3.4: Thermion Inc. has a patented cored aluminum wire, made in two varieties for nonskid coatings and other wear applications. Our TH-604 has "ceramic" aluminum oxide core, the TH-605 has a silicon carbide core. In a corrosion environment each performs exactly like aluminum, both materials have been applied on stainless with success. The wear properties are tenfold that of straight aluminum. The U.S. Navy had little success in using pure aluminum for nonslip; except to provide excellent corrosion protection, the wear properties were not satisfactory. This invention, "ceramic cored aluminum," was a result of the early Navy work.

Question 4

Powder flow rate for plasma spray systems. I am looking for guidelines to a typical versus an excessively high flow rate for powder used for plasma spray. For example, 6 to 7 lb/h is typical, but spraying in the range of 12 to 17 lb/h of powder would be excessive. This excess of powder would simply fall to the floor. I understand the above spray rates are commonly accepted; however, I have not found anything in writing.

Answer 4.1: Optimal powder feed rates are developed for different powders based on the melting point of the powder and the available heat for the process. If available heat is constant, usually 40 kW, increasing powder feed rates will indeed cause powder to be wasted because there just will not be enough heat to effectively melt all the powder. It is theoretically possible to overwhelm the plasma with so much powder that none of it melts. Higher powder feed rates require equipment with higher power.

Answer 4.2: I believe that the water-stabilized plasma (WSP) torch developed in the Czech Republic can spray ceramics such as alumina at feed rates of up 200 lb/h.

Answer 4.3: Attempting to run at the highest powder flow rate with the best efficiency is something not easily achievable. Without doing proper quality control (specimen analysis), substantially increasing your feed rate may run the risk of producing a coating of poor quality and ultimately a reject or nonconformance and not to mention excessive waste due to poor efficiency. It is through development and testing that you establish the parameters that best suit your needs. The three major elements for success are the highest level of deposition efficiency,

which obtains the best possible quality, processed in the least amount of time. A lower feed rate can in some cases produce excellent results depending on the material being sprayed, but at what cost if the deposition rate is so low that you lose too much production time? The inverse is also true, when the feed rate is increased, you might decrease your overall production time but run the risk of nonquality costs, having to repeat the operation a second time or worse a third. A small increase in deposition rate by increasing the feed rate can also translate into greater efficiency losses causing you additional operational costs. It becomes an issue of balance.

Question 5

Grinding the edges of HVOF sprayed rolls. Can anybody suggest the procedure to maintain the edge even after spraying and grinding? As I understand, coating on the edges shall have a poor bonding, and during grinding there are chances of peel off. In fact, I want to get a HVOF coating on the roll diameter and on the sides and grind them to achieve different surface finish.

Answer 5.1: HVOF carbides can have cracking problems at sharp outside corners due to residual compressive stresses. This can be reduced or eliminated by adding more heat to the powder, more matrices to the carbide, or increasing the radius. More heat and decarburization or a larger matrix fraction will of course reduce hardness and wear resistance in most applications.

Question 6

Dye penetrant test to evaluate porosity. We are currently spraying a WC on two sleeves with a Top Gun torch. A third-party inspection has rejected twice the job on the ground for having too much porosity. The evaluation was done via the dye penetrant test (DPT), and after the developer is applied the surface became "pinkish." No cracks, but his assumption is that the surface must be white. Is it possible that the substrate has an adverse effect in porosities level? How critical is the level of porosity? We know that thermal spray coatings are porous by nature, but for HVOF, is DPT the ultimate method of tracking those porosities?

Answer 6.1: We have had some experience with being unable to meet a dye penetrant test with the Diamond Jet system. The coating was Inconel 718. We were able to pass the test consistently with a JP 5000.

Answer 6.2: If you are able to use hydrogen as fuel, you may want to consider the JK120H. This powder has a fine powder distribution. When applied with Jet Kote it produces porosity levels typically lower than 0.5%. It has demonstrated the ability to pass dye penetrant tests after grinding the coating. It also does not allow sour gas, hydrogen sulfide (H_2S), to penetrate when it is properly applied and finished.

Answer 6.3: Is this to suggest that this coating, after grinding, could be considered to be a moisture barrier coating since it passes a DPT?

Answer 6.4: Not really. The DPT cannot be used for such evaluation. Such test will also "fail" the coating if pores are present only in the surface layer, and yet the remaining coating can be fully dense.

Answer 6.5: This coating has shown that it has a very low permeability for hydrogen sulfide gas both dry and wet conditions, so I suspect it could be considered a moisture barrier as well.

Answer 6.6: You might be able to achieve lower porosities with the DJ using finer powders and a lot of work with parameters.

Answer 6.7: If you use too much dye and do not remove it properly, then the white developer will turn solid pink. If the test is done correctly, small cracks or porosity will show, but it should not be a solid pink color. A solid pink color is a sign that too much dye was left on the coating.

Question 7

Nonstick coating. How can I get nonstick surface on aluminum pipe? It also must resist wear while guiding paper on it. Is it possible by thermal spray? If so what kind of powder should I spray?

Answer 7.1: Combining a thermal spray coating such as arc wire with a liquid system like Teflon is commonly done to produce the coating properties you are looking for.

Answer 7.2: I would suggest that you consider the quasi-crystalline materials available from Norton/Saint Gobain. They have a very low coefficient of friction and are fairly hard so should give you a nonsticking, wear-resistant surface. The materials, in powder form, are applied by plasma spraying.

Answer 7.3: We apply several types of coatings using either tungsten carbide or ceramics with a fluoropolymer top coat for nonstick and low coefficient of friction.