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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.asminternational.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

Using O_2 and N_2 in arc spray. Can we safely use oxygen or nitrogen in arc spray, both for atomizing as well as to run air motor if dry compressed air is not available?

Answer 1.1: I would not use oxygen under any circumstances. Any organics or grease present could cause a fire or worse. This is the same basic safety issue about not putting grease on pressure regulators on gas cylinders.

Answer 1.2: Dry nitrogen sounds okay. In some systems there is just one gas supply, which provides the drive and atomizing gas. Depending on what is being sprayed there is always the possibility of forming unwanted compounds in the deposit, e.g., both aluminum and titanium form nitrides.

Answer 1.3: Regarding the use of nitrogen instead of air as the arc spray atomizing gas: with some stainless steel and nickel alloys, pure nitrogen can cause the two wires to melt at differing rates, leading to intermittent spitting. It is also worth considering carbon dioxide as the atomizing gas (you will probably need a special heater to keep the gas valve/gauge from freezing; these are available from some welding suppliers). CO_2 acts a lot like argon but is much less expensive.

Answer 1.4: For safety precautions, I would avoid the use of oxygen but nitrogen would be acceptable, as would argon.

Question 2

Spraying carbides without binder. Is it possible to spray carbides (WC or B_4C) by HVOF (high-velocity oxyfuel) or APS (atmospheric plasma spray) without any binder?

Answer 2.1: Some 20 years ago we used to spray B_4C by plasma and the coating was pretty good.

Answer 2.2: I do not see any reason why it should not work. However, it should produce hard, brittle, ceramic coatings, i.e., not necessarily too wear resistant without the ductile binder to support the carbide phase. It depends on the intended application.

Question 3

Corrosion-resistant coating for crude storage tank. We have received an enquiry for corrosion-resistant coating on internal surface of crude storage tank. The bottom portion of the tank is heavily pitted. We are planning to put patch plates on this area and spray with 316 SS and seal with sealant. I would like to know the suitability of 316 coating. Will it cause any effect on the uncoated portion? Is there another material that can be sprayed without any detrimental effects?

Answer 3.1: Zinc, aluminum, or a zinc/aluminum alloy would be better choices, for either will provide sacrificial anode protection; however, a small sprayed area may sacrifice very quickly. I would suggest spraying as much area the owner would allow.

Answer 3.2: You would be better off pouring concrete and sealing with epoxy. Pitting is because of corrosion by water under the crude and the sediment that builds in tanks over time. Zinc or aluminum coatings will not work due to the lack of O_2.

Answer 3.3: Since the conditions in the bottom of crude oil storage tank always become acidic, zinc or aluminum are not viable candidates. The SS 316 is a more suitable candidate if there are supporting case histories. Standard practice for this service is to apply glassed filled vinyl ester coatings to the floor and one meter at the bottom of the side shell. The vinyl ester may also be used to cement the steel patch plates where required. The technique will also preclude requiring "hot work" permits. Specialist coating suppliers will provide details.

Question 4

The purity of gases for thermal spray. Does anyone know the minimum purity for oxygen, fuel gases (used on flame spray process, such as: acetylene, hydrogen, propane) and plasma forming gases (such as argon, nitrogen, hydrogen) for thermal spray torches?

Answer 4.1: When it comes to plasma the gases must be 99.997% or better. For troubleshooting our customers problems with their coating issues, we have found that people buying 99.995% (welding grade) are playing "roulette." The bottles do not have to be vacuumed or purged in this grade, and people that leave the bottles open will draw in air/moisture from the outside. If that is left unpurged, then you get someone's problems, causing you a very bad day. Leaks in pipes and within the system can cause good gas to be made bad by drawing in air with the gas due to the low pressure along the walls as gas is flowing.

Answer 4.2: Four nines, (99.99X%) is fine for oxyfuel, but I have found that plasma requires five nines (99.999X%). Water is a by-product of combustion with most fuel gasses; a moisture content of .00X% has a minimal or negligible effect on flame enthalpy. I do recommend that the gases used in an oxyfuel process be of a consistent quality so that the process is reproducible. Parameters that work fine at a low moisture content will produce an inferior coating at higher moisture levels. Conversely, parameters developed for higher moisture content may produce excessive oxides when used with dryer fuel.

Answer 4.3: When the spray system is ready to run, it is important to determine the gas compositions actually entering the gun and powder feeder, to make sure no undesirable impurities, including moisture, are picked up in the gas delivery system because of leaks, contamination, etc. Industrial gas suppliers can be called upon to make this determination and suggest any needed remedial actions.

Question 5

Sealing thermally sprayed dielectrics. Does anyone have any specifics on thermally sprayed materials and processes that, when used in combination over the top of a sprayed ceramic dielectric layer, will provide moisture migration protection? We are well aware of the fact that these porous dielectric materials absorb ambient moisture over time, which significantly compromises the insulation resistance of the coating.

Answer 5.1: I have successfully used a 100% solid epoxy to seal thermally sprayed dielectrics. The material we used was capable of being cured using heat or microwave energy.

Answer 5.2: Depending on the operating temperature perhaps a sprayed polymer matrix ceramic reinforced composite coating could act as a sealant and moisture barrier? Some of our HVOF sprayed nylon 11-silica coatings have show very low water vapor transport. Some polymers, such as thermosetting polyamides have quite high operating temperatures.

Question 6

Coatings for automotive valves. Have Mo-Ni-Cr plasma sprayed alloy coatings been used successfully for automotive valves (combustion engine)? To what operating temperature can such alloys be used?

Answer 6.1: Operating temperature for Mo/Ni/Cr is up to 350 °C (660 °F).

Answer 6.2: Piston rings for gas and diesel engines are coated with Mo/Ni/Cr.

Question 7

Sealing coatings after penetrant test. Some of our customers have OEM repair procedures for industrial applications (nongas turbine, nonaviation) requiring dye penetrant testing on the thermal spray coating after grinding.

1. It seems that the dye penetrant and cleaners exhibit very light viscosity and therefore would enter any coating porosity (that is the purpose of the penetrant), and this would cause any sealant applied later to have much less of a sealing action?
2. Sealants, anyone with industrial application experience, especially for reciprocating sliding applications (plungers, rams, hydraulic pistons) have information on the usefulness (increase in service life, decrease in failures) of thermal spray coatings in applications subjected to high pressure from seals, and hydraulics (considering that pressure is the main concern, and corrosion is much less of a factor in the wear).

Answer 7.1: If the crack detection is the objective of carrying out penetrant test, do consider eddy current testing. Issues related to chemicals are not encounter in eddy current testing. Cost-wise, it can be higher.

Answer 7.2: We use alcohol or acetone splashed over coating surface, watching the front of vaporization (may use a small fan for alcohol). Cracks are revealed due to lower rate of liquid vaporization from them. Very efficient for smooth surfaces and does not affect sealing afterward. However, you cannot make pictures.

Question 8

Finishing thermal spray coatings with CNC machines. I will appreciate your comments about finishing thermally sprayed coatings with CNC machines (lathes or work stations).

Answer 8.1: The U.S. Air Force does some single point and grinding to get back to OEM specs. If you go slowly, have good bonding; it will be ok to cut coatings.

Question 9

Shield dark glasses for thermal spray booths. I would appreciate some information about where do I get shield dark glasses for thermal spray booths? Is it UV 8 or UV 9? The size of glass frame is 600 × 600 mm.

Answer 9.1: The more affordable way to protect your personnel is with a welding shade (tinted plastic curtain) in front of safety glass—readily available at most welding supply houses.

Answer 9.2: We use tint for car windows on our spray booths. About two to three layers thick.

Question 10

Coating carbon fibers using thermal spray. We have been asked if it is possible to apply a wear-resistant coating, by a thermal spray process, onto components manufactured from carbon fiber. Has anyone any experience, either successful or unsuccessful at this?

Answer 10.1: At our institute we did research on the application of a wear-resistant coating on components such as carbon reinforced carbon rollers about 10 years ago. We could successfully apply an alumina-titania coating and also a WC/Co coating. The main solution method was the design of a suitable type of "bond coat" to achieve satisfactory bonding; since typical applied surface activation by grit blasting etc. is severely damaging the substrate surface and are not applicable.

Answer 10.2: On a project funded by NASA we developed some FGM Polyimide to WC-Co graded architecture coatings applied to PMR-15/C-fiber composite substrates for improved solid particle erosion resistance. Here are some published references:

- M. Ivosevic, R. Knight, S.R. Kalidindi, G.R. Palmese, and J. K. Sutter, Adhesive/Cohesive Properties of Thermally Sprayed Functionally Graded Coatings for Polymer Matrix Composites, *J. Thermal Spray Technol.,* Vol 14 (No. 1), March 2005, p 45-51
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- M. Ivosevic, R. Knight, S.R. Kalidindi, G.R. Palmese, and J.K. Sutter, Microstructure and Properties of Thermally Sprayed Functionally Graded Coatings for Polymeric Substrates, *Proc. 2003 International Thermal Spray Conference (ITSC-2003)* (Orlando, FL), May 5-8, 2003, B.R. Marple and C. Moreau, Ed., ASM International, 2003, p 1667-1673
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- R. Knight, M. Ivosevic, S.R. Kalidindi, G.R. Palmese, and J.K. Sutter, Solid Particle Erosion Resistance of Thermally Sprayed Functionally Graded Polymer/Ceramic Coatings, *Proc. 2004 International Thermal Spray Conference (ITSC-2004)* (Osaka, Japan), May 10-12, 2004, DVS/IIW/ASM-TSS
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Question 11

High-temperature sealer. I would appreciate your help on selecting a high-temperature sealer for a nickel-base alloy coating on copper by HVOF. The exposure temperature will be under 204 °C (400 °F). Aremco has one that requires curing at 370 °C (700 °F) for 1 to 2 h. Heating is not practical due to the size of the part.

Answer 11.1: You could use Diamant Dichtol from Germany works up to 500 °C (930 °F). I have used this for several years on HVOF coatings also arc spray and sealing cast iron welds.