Cold Spray Technologies Forum - Questions & Answers

"Overview of Cold Spray Technology for DoD and the Commercial Sector", Victor Champagne, US Army Research Laboratory, Director, ARL Center for Cold Spray

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Questions (24)

Q1: Why do the particles need to be heated to such high temps prior to deposition?
A1: You don't necessarily have to use those temperatures. Sometimes we spray at room temperatures. It depends on the material you are trying to spray. You want get what we call a "critical impact velocity", which is influenced by a material's ductility, melting temperature and ability to deform. Different materials have different critical impact velocities.

Q2: Vic, who manufactures the nano-5083 powder you tested?
A2: Two places: Dr. George Kim at Perpetual Technologies, funded by ONR, makes a non-structured powder. Another company, Eltron Research & Development, located in Boulder, Colorado, are using nano particulates to make a cold spray powder.

Q3: Vic, are you resourced by OSD Mantech to accomplish the mission outlined?
A3: This will be covered later by Brian James during the Air Force presentation.

Q4: Does the additive manufacturing use require a mold?
A4: It depends on what you are trying to do. We use molds on some applications, some not. There has to be support somewhere.

Q5: Is it MLSTD- 2031 or 3021? It was said both ways.
A5: MIL-STD 3021 DOD Manufacturing Process Standard Materials Deposition, Cold Spray

Q6: Seems very airframe component centric in applications. What about ground gear, and ships??
A6: Absolutely. We have dozens of applications. A lot of mine now are medical. Aerospace applications opened the door. Selective galvanizing was an early automotive project. We are currently working with chrome replacement on M1 tanks and copper with motherboards on electric vehicles. We are also working on periscopes with NAVSEA as well.

Q7: Can this process be used to repair general corrosion on A-36 steel *(A36 steel after heat treating is >60 HRC)*?
A7: It depends on the relative hardness of the material. If you have an HRC of 50 or greater it will be very difficult to get the adhesion required for corrosion resistance. With an HRC of 40 or below, yes. With an HRC of 60, no, I would not go that way.

Q8: Can this process be used inside a standard shrink wrap blast containment?
A8: It is material dependent. For example, if it involves grit blasting fine materials, the material will get into everything. That may or may not be an issue in the particular application.

Q9. Will cold sprayed steel be welded using any or all welding processes using 70XX and 80XX filler material?
A9: Please get with Vic off-line.

Q10: Has much testing been done on fatigue properties of cold spray repaired materials and how does it compare to parent material?
A10: Excellent question. I have 30 years at ARL, and a lot of work in coating development. Sikorsky initially raised the bar with the test requirements to qualify Cold Spray. I've never seen the amount of test requirements needed for the magnesium repair. I have tons of repair data. It doesn't give you a debit in the materials we investigated.

Q10 (Follow-up): Is there a standard fatigue protocol for testing cold spray repaired components?

A10 FU: What we did, the test matrix developed under the ESTCP program was modeled under the HCAT. Initially, we took the test protocol established for Tungston-carbide cobalt coatings applied by HVOS. That was our skeleton, and we worked from there. We use ASTM standard test samples and developed a joint test protocol (JTP) of our own with input from Army, Navy and Air Force. We also do fretting fatigue testing. We have already satisfied 90% of requirements for structural repair. All we have to do is component testing. However, everything is material dependent.

Q11: For use on steel, what is the minimum/maximum deposit rate?
A11: Dependent on material is being deposited. For example, we can lay down about 30 lbs of aluminum on steel per hour.

Q12: Was the aluminum powder you used to gain 7% elongation deposited with a low pressure or high pressure system? Or have you obtained this elongation with both systems?
A12: There will be a powder spec out this year. You will need a high pressure system.

Q13: Is there any data from DoD weld engineers available?
A13: I don't understand the question. I suspect it involves weld specifications. The answer is yes. We actually go well beyond AWS specifications. We do impact test, bend tests, fretting tests, etc. The JTP would include the AWS specifications. People should get the ESTCP report.

Q14: What is the lower limit for stand-off distance (and impingement angle)? For example, what interior diameter of piping (if any) can be coated/treated, and how far into the pipe entrance is coatable?.....Are 'approved repair processes' (e.g., mentioned by Vic Champagne) usually publicly available ('Distribution A' or equivalent)?
A14: Typical distance is 3/8 to 1/2 inch. Impingement angle is material and substrate dependent. Ninety degrees is not always the optimal angle.

Q15: Is anyone using this technology on steel-routinely?
A15: Again, please get with Vic off-line.

Q16: Are there residual stresses on substrate due to cold spray?
A16: Yes, the magnitude is dependent on material and substrate. The harder the substrate, the less deformation occurs. For example, Aluminum and Magnesium have similar properties, and go very well together.

Q17: How loud (dB) is this process application?
A17: You have to wear standard hearing protection. I don't know the db level.

Q18: Is it possible to use NICU for hatch liners?
A18: Question was not asked.

Q19: What entity will have the most impact in producing CS specifications - the OEM, owner (DoD / commercial aircraft operators), FAA repair shops, 3rd parties ? Where should we focus in producing specs? Job shops will only spray to a specification.
A19: I receive input from all of the above, including industry, AMCOM, NAVAIR, and academia. When it comes down to the development of specifications for specific applications, those will probably be spearheaded by the industry leaders in that particular field.

Q20: Could we "weld" parts together with cold spray in materials that it could be considered a structural application?
A20: We are exploring that area now and have demonstrated the capability on some proprietary applications for the DoD and DOE.

Q21: It seems this process/product could be useful in production (prophylaxis), as well as in repair. Have there been any OEMs willing to apply these coatings in the production process, perhaps as part of a "reliability improvement program" for a PBL contract?

A21: Yes, Boeing has already done it. Sikorsky has done it, too. Generally, you are repairing castings.

Q22: For repair operations, does the cold spray provide structural integrity to the repaired component?
A22: It can depending on the substrate and coating materials. This has been proven through fatigue testing and materials characterization.

Q23: Can cold spray coatings be welded?
A23: I am performing such experiments using aluminum and magnesium alloys this quarter, but we have soldered copper cold spray deposits for electronics applications that were successful.

Q24: Is cold spray used to apply thermal/erosion resistance coating on gas turbine engine blade materials?
A24: If you are referring to the typical Thermal Barrier Coating or 'TBC' which consists of partially stabilized zirconia (PSZ) cold spray cannot be used to spray a 100% ceramic coating to any appreciable thickness. We have developed alternative thermal coatings that are erosion/wear resistant but for other applications.

"NAVAIR Cold Spray Initiative Update", Fred Lancaster, NAVAIR Materials Engineering Division

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Questions (10)

Q1: What is the base material of the ring gear that is copper coated?
A1: I don't remember. It could be 300M or Aermet 100. Vic later added that it is a Nitrite steel that has an HRC less than 40 where the work was performed.

Q2: Who is the point of contact at NSWC?
A2: At Carderock, it's Dr. Jenn Wolk. At Keyport it's Dr. Brian Mahoney.

Q3: Is Fred Lancaster's presentation file available for download? Don't see it listed in the presentation files Pod.
A3: All the presentations are combine in the pdf file which is at the bottom of the DCO screen. Additionally, the presentations will be available on the JTEG website at http://jteg.ncms.org/

Q4: Did you spray 300M powder onto 300M substrate? What adhesion strength did you attain?
A4: No, we haven't sprayed 300M powder. We have sprayed aluminum powders onto 300M for repair.

Q5: What kind of collaborative efforts does NAVAIR have with NAVSEA?
A5: We have had a technical exchange of personnel for 2 years. In addition, NAVSEA holds a monthly teleconference meeting between NAVSEA and NAVAIR to discuss several ongoing projects.

Q6: What do you do to clean and prep a corroded airframe area for cold spray repair and to what extent does the surface need to be cleaned?
A6: For the repairs that we've done, we've ground out those areas to a certain depth/width ratio. We clean it with a solvent cleaner, maybe an aluminum oxide abrasive, then fill it back up with the material.

Q7: This is a query for Vic Champagne: Any cold spray application on Ceramic parts?
A7: Yes, there is. Used as an additive process to add copper conductors to ceramic. It is much faster than subtractive methods.

Q8: What is the axel pin material?
A8: Not sure on the base steel, most likely a High Strength Steel, but the process was not to coat the axel pin, it was to apply a repair coating to the Nickel Cobalt Phosphorus (nCoP) coating.

Q9: What is the added value of Al by Cold Spray vs a conventional Al paint like Sermetel or Alseal in terms of Corrosion resistance
A9: Cold spray aluminum provides a highly dense coating for repair of IVD coatings for what we are repairing it is not in the high temp region of the aircraft – mainly HSS used on landing gear. Our applications are not to be compared to gas turbine coatings such as Serme Tel and Alseal that are used on high temperature areas of gas turbine engines.

Q10: Have you fielded any repairs that completely restore the strength of the part?
A10: No we have not. If it is a structural repair we consider the part to be non-serviceable at that point. Therefore we have not focused our testing or efforts in that area, mainly as we do not have the need.

“Air Force Advances in Cold Spray”, Rob Hrabe, H.F. Engineering Services, Chief Executive Officer, and Brian James, 28th Maintenance Group

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Open Questions (5)

Q1: How much did the USAF leverage previous work done by ARL and NAVAIR when developing and qualifying the AF Gearbox repairs?
A1: On the Air Force side it was completely leveraged. Air Force effort came on after Army and Navy and used the lessons learned. We did have to re-prove some data with our own testing and individual testing for each part.

Q2: What company actually manufactured the OSD MANTECH cold spray automation machine?
A2: H.F. Webster was the prime contractor for the motion system. A company called Flexible Robotic Environment did the software, Cybernet and Souty Dakota School of Mines worked the integration efforts.

Q3: Aside from checking dimensions, what non destructive testing do you do?
A3: Question was not asked.

Q4: Will the portable system go through ship hatches?
A4: The current configuration will not. We are working on a smaller version that in theory could even go on a submarine. It is clearly possible. Current system is about 500 lbs.

Q5: How was B1 FEB panel repair qualified?
A5: We found the repair qualifications from OO-ALC. We submitted an Engineering Technical Request (ETR) asking for authorization to repair. Qualifications included adhesion testing, tensile testing, elongation of 3 percent or greater, bearing load test, and standard porosity and microscopy measurements.

“Navy ManTech Cold Spray”, Timothy Eden, Ph.D., Applied Research Laboratory/Penn State, Head of the Materials Processing Division

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Questions (5)

Q1: How thick is the anti-fret coating on the airfoil "fir tree"?
A2: We put it on as thick as ¼ inch, and we machine it back to a few thousands of an inch depending on the application. The coating machines very well.

Q2: Is there data comparing lubricity & wear resistance of cold-sprayed Ni/h-BN to those applied from solution (electroplated or autocatalytic/electrolysis Ni bath with suspended h-BN {or PTFE} powder)?
A2: Question was not asked.

Q3: Is anybody using this cost model for making business decisions on whether to use cold spray or not? CenterLine uses a similar, comprehensive cost estimate tool.
A3: We just got it released so we can send it out. Pratt Whitney has a copy. We use it routinely to show cost estimates and determine feasibility of using cold spray.

Q4: Did you test if spraying the blade root with the hBN weakens the part at this critical place?
A4: Question was not asked.

Q5: (Comment) Thanks all for your work putting this together. Very informative and worthwhile!